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Indirect Effects

Assessments of indirect effects, as well as cumulative effects, are required by the National Environmental Policy Act (NEPA) and the Council on Environmental Quality (CEQ). The importance of indirect and cumulative effects analyses in the NEPA process has been emphasized by a number of federal court decisions and research studies. These directives were summarized by the Texas Department of Transportation (TxDOT) in a September 2010 guidance document, which requires that for Environmental Impact Statements (EIS), Environmental Assessments (EA), and some Categorical Exclusions (CE), indirect and cumulative effects assessments shall (1) be addressed individually in separate sections of the environmental document; and (2) follow prescribed step-wise methodologies. Preserving the distinction between indirect and cumulative analyses in environmental documents is important because of key inherent differences in the nature of the effects and the ways in which they are identified and measured. For example, indirect effects: (1) are caused by the proposed action; (2) are analytically focused on the impact-causing activities associated with the proposed action, its alternatives and the environmental impacts associated with those activities; and, (3) occur later in time and are farther removed in distance from the proposed project area when compared to direct effects. Cumulative effects analyses, on the other hand: (1) are more resource-focused; (2) consider a range of impact-causing activities beyond the scope of the proposed action; and, (3) may include past, present and future actions either near to or some distance away from the proposed action.

This section was developed using TxDOT's September 2010 Revised Guidance on Preparing Indirect and Cumulative Impact Analyses, which is based on the 2002 National Cooperative Highway Research Program (NCHRP) Report entitled, *NCHRP Report 466: Desk Reference for Estimating the Indirect Effects of Proposed Transportation Projects* (TxDOT 2010e; NCHRP 2002). Other sources of guidance include the NCHRP Project 25-25, Task 22 report entitled *Forecasting Indirect Land Use Effects of Transportation Projects* (Avin et al. 2007) and a University of Texas at Austin Center for Transportation Research (CTR) study entitled *Research on Relationships between Transportation Infrastructure & Increases in Vehicle Miles Traveled: The Effects of Highway Capacity Expansion on Land Development* (Kockelman et al. 2001).

The CEQ rules define indirect effects as effects "…which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems" (40 CFR 1508.8(b)).

The NCHRP Report 466 identifies three broad categories of indirect effects (NCHRP 2002):

1. Encroachment-alteration effects. These effects may result from changes in ecosystems, natural processes, or socioeconomic conditions that are caused by the proposed action, but occur later in time or farther removed in distance. Examples include long term changes in stream hydrology downstream from a waterway crossing or gradual effects on a neighborhood's cohesion as a result of roadway encroachment, displacements, or changes in access.
2. Project-influenced development effects. Sometimes called induced growth, or the "land use effect". For transportation projects, induced growth effects are most often related to changes in accessibility to an area, which in turn affects the area's attractiveness for development.
3. Effects related to project-influenced development. These are impacts to the natural or human environment that may result from project-influenced changes in land use.

As noted in the NCHRP guidance, "[i]ndirect effects can be linked to direct effects in a causal chain" (NCHRP 2002).

The NCHRP Report 466 further describes an eight-step framework for identifying and analyzing the potential indirect effects for significance (NCHRP 2002). TxDOT's September 2010 guidance combines Steps 6 and 7, reducing the total number of steps to seven. The seven steps are presented in **Table 4-1**.

Table 4-1: Seven-Step Approach to Estimate Indirect Impacts

Step	Description
1	Scoping: The basic approach, effort required, and geographical boundaries of the study area are determined.
2	Identify the Study Area's Goals and Trends: Information regarding the study area is compiled with the goal of defining the context for assessment.
3	Inventory the Study Area's Notable Features: Additional data on environmental features are gathered and synthesized with a goal of identifying specific environmental features that are valued, vulnerable, or unique. This step also contributes to defining the context for the analysis.
4	Identify Impact-Causing Activities of Proposed Action and Alternatives: Fully describe the component activities of each project alternative.
5	Identify Potentially Substantial Indirect Effects for Analysis: Indirect effects associated with project activities and alternatives are cataloged, and potentially significant effects meriting further analysis are identified.
6	Analyze Indirect Effects: Qualitative and quantitative techniques are employed to estimate the magnitude of the potentially significant effects identified in Step 5 and describe future conditions with and without the proposed transportation improvement. Evaluate Analysis Results: The uncertainty of the results of the indirect effects analysis is evaluated for its ramification on the overall assessment.
7	Assess Consequences and Develop Mitigation: The consequences of indirect effects are evaluated against the context of the project to determine their importance. Strategies to avoid or lessen any effects found to be unacceptable are developed. Effects are reevaluated in the context of those mitigation strategies.

Source: TxDOT, September 2010.

4.1 STEP 1: SCOPING

The main objectives of the scoping process are (1) to determine the level of effort and general approach required to complete the study, and (2) to determine the location and extent of the study area. The products of this step are a work plan outlining the methodology and assumptions to be used in the analysis and a map showing the aerial extent of the Area of Influence (AOI).

4.1.1 Determining the Appropriate Methods and Level of Effort

The initial task in defining the scope of the indirect effects analysis is to establish the context of the project, which will help determine the most appropriate approach and level of effort.

The purpose of the proposed project is to: provide transportation improvements that accommodate travel demand generated by historic and anticipated future population and employment growth within the United States (US) Highway 281 project corridor; enhance mobility and accessibility within the corridor; improve traffic safety; and enhance quality of life for users of the roadway and the surrounding community.

The project is consistent with local, regional and state transportation plans and policies, including the Metropolitan Transportation Plan (MTP) (*Mobility 2035* and *Mobility 2040)* produced by the Alamo Area Metropolitan Planning Organization, formerly known as San Antonio-Bexar County Metropolitan Planning Organization (MPO), and the Statewide Transportation Improvement Program (STIP) for the TxDOT San Antonio District. The project is a response to existing and projected growth in population and traffic as well as the need to improve safety and community quality of life.

The extent to which the proposed project is likely to influence local and regional land development location decisions is a central question in scoping the indirect effects analysis, and will be addressed more fully in **Section 4.6 Step 6: Analysis of Indirect Effects and Evaluate Results**. This analysis will rely on Census and MPO data and projections, state and local regulations, aerial photography, Geographical Information Systems (GIS) databases and other sources to generate assessments. Given the uncertainty inherent in predicting indirect impacts, some qualitative assumptions and assessments are necessary, including the collaborative judgment of local planners, officials, and land use experts (the Land Use Panel) regarding anticipated development trends and associated travel demand. The composition and contributions of the land use panel through two workshops held in the summer of 2010 are described in detail in **Section 4.6.2 Induced Growth Effects**.

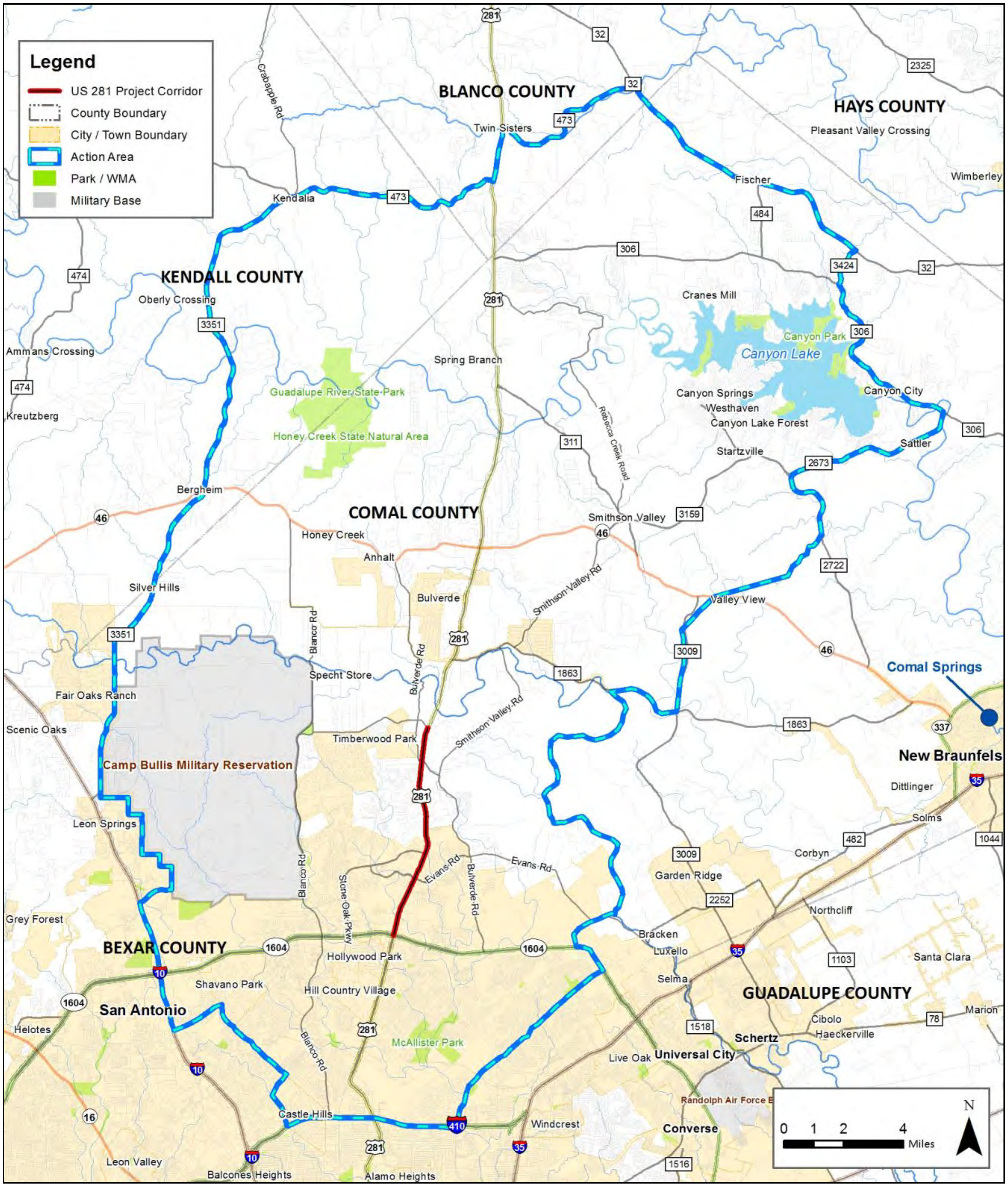
4.1.2 Study Area Boundaries: Area of Influence (AOI)

The AOI represents the geographical area within which the probable encroachment-alteration and induced land development effects of the proposed project are likely to occur for the Indirect Impacts assessment.

Methods and Assumptions for Developing the AOI

The AOI covers 356,547 acres, approximately 560 square miles, in northern Bexar, western Comal and small parts of Kendall and Blanco counties (**Figure 4-1**). The geographic area mapped on **Figure 4-1** is primarily oriented to the analysis of induced development, or the “land use effect,” of the proposed project. As such the map does not reflect the potential encroachment-alteration groundwater quality effects that could result from aquifer flow paths extending beyond the mapped AOI boundary. For example, the groundwater flow paths described in **Section 3.9.2 Groundwater** and depicted on **Figure 3-34** have the potential to carry contaminants from the project area as far as Comal Springs, which contains habitat for several federally-listed threatened and endangered species. For this reason potential indirect impacts of the proposed project were evaluated for the Comal Springs species. Comal Springs is therefore considered to be within the encroachment-alteration AOI in the Indirect Impacts analysis; it is also located within the Groundwater Resource Study Area defined in **Chapter 5** for the analysis of Cumulative Impacts. Given the methodological emphasis on the important issue of induced development – which is focused on surface land use effects associated with transportation and access improvements -- the land surface map of the AOI does not reflect the inclusion of Comal Springs. However, the potential indirect impacts to Comal Springs habitats are addressed in **Section 4.6.3 Effects Related to Induced Growth**. The land use AOI shown on **Figure 4-1** was developed using a combination of methods, including: (1) a select link analysis utilizing the MPO's 2035 travel demand model; (2) an analysis of travel time estimates for trips utilizing the corridor; (3) consideration of the competing influence of other major roadways, like Loop 410; (4) other minor adjustments in consideration of observed development patterns; and (5) consideration of the recommendations from the US 281 EIS Land Use Panel.

Figure 4-1: Area of Influence



Source: US 281 EIS Team, 2010

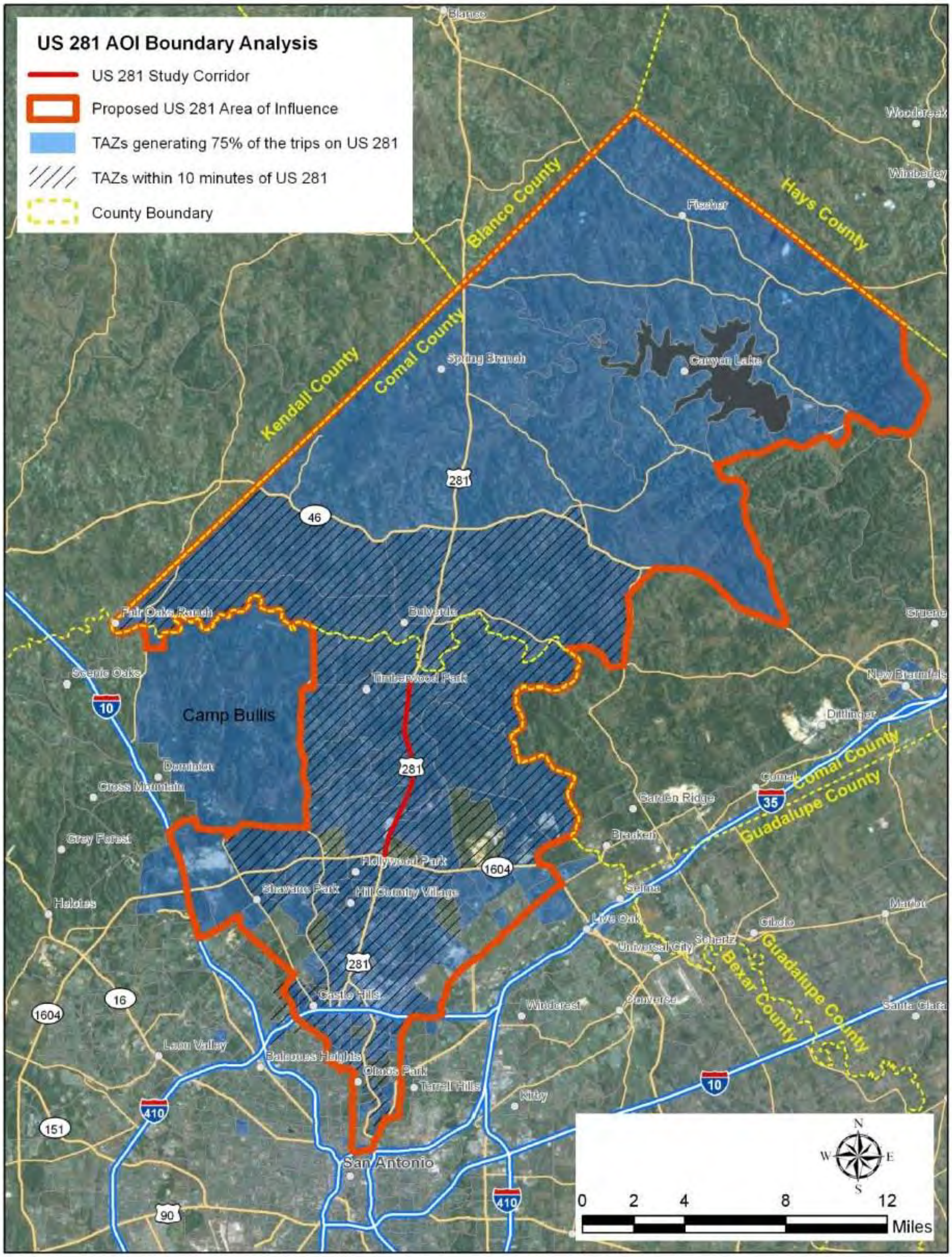
The travel demand model is a planning tool that provides estimates of future traffic patterns utilizing the roadway network given population and employment forecasts. The tool allows the user to select a specific roadway link within the network, such as a portion of US 281 in the study area, and highlight the origins and destinations of traffic that use this link. The results of this select link analysis yield a matrix containing trip data for origin and destination Traffic Analysis Zones (TAZ). These data help determine the geographical area that has a notable influence on trip travel on US 281 within the project limits.

The select link analysis was performed for the 2035 roadway network adopted in *Mobility 2035* and uses 2035 trip tables from the adopted MPO demographic forecasts. The select link analysis was performed for the segment of US 281 north of Loop 1604 which has the highest existing and forecasted traffic volumes on US 281 in the project study area in order to develop the area of influence that is inclusive of most of the trips along US 281 corridor.

The select link analysis was used to display the geographic area that generates approximately 75 percent of the travel that occurs on the US 281 select link. The process identified a set of TAZs that form this geographic area. At least 1.5 percent of the trips generated in each individual TAZ in this set travel on the US 281 select link. The resulting area, shown as the "Preliminary AOI" on **Figure 4-2** with the color blue, was used as one reference for the development of the AOI boundary, in conjunction with the area determined using the travel time methodology described below.

The travel time-based method used the average commute time of 25 minutes for Bexar County (US Census Bureau 2008b). This was rounded up to 30 minutes for the year 2035 to address potential increase in travel time related to future growth in the region. The 30-minute total travel time was split into 10 minutes blocks, 10 minutes travel time to reach US 281 from an origin, 10 minutes travel time on US 281, and 10 minutes travel time to reach the destination from US 281. A buffer was created around US 281 to represent areas accessible to US 281 within 10-minutes. The resulting area, shown in **Figure 4-2** with diagonal hatching, was used as a second reference for the development of the AOI boundary.

Figure 4-2: Preliminary AOI based on select link analysis



Source: US 281 EIS Team, 2010

The areas indicated by the two technical approaches were layered on an aerial map. The process to determine the AOI referenced the boundaries from the select link and travel time methods as well as current development patterns observed from the aerial mapping. The land uses within the AOI generate a majority of the trips along the US 281 project corridor — approximately 73.5 percent. The majority of the TAZs within a 10-minute travel time were included in the AOI boundary. Some TAZs that contributed to the 75 percent of trips on the US 281 link were excluded based on the following reasons:

- TAZ was not adjacent or contiguous with other TAZs that formed the AOI boundary
- TAZ was a special zone (e.g., Camp Bullis)
- TAZ was on the opposite side of a competing facility like IH-10, IH-35, or Loop 410
- Inclusion of a TAZ led to an irregular AOI boundary while contributing a relatively smaller number of trips to the link on US 281

Another adjustment to the final AOI was made to avoid excluding parts of Kendall County, which the select link method did not address because the *Mobility 2035* surveys for current travel patterns show very low origin-destination data for the TAZs beyond Comal County. To avoid this exclusion, the AOI western boundary was extended along existing roadways (FM 32, FM 473, and FM 3351), which could provide access to areas subject to development influence in the later years of the 2035 planning period.

At workshops held in June and July of 2010, Land Use Panel participants were asked to provide comments and suggestions regarding the geographic area included in the AOI. The composition of the Land Use Panel included people with substantial local knowledge about individual properties, particular land parcels, local zoning and real estate conditions, and environmental issues in the area. The group reflected diverse approaches to land use and development issues, drawn from the fields of academia, real estate, land use, transportation and policy planning, and economics, as well as informed lay persons (See **Section 4.6.2 Induced Growth Effects**). The methods for selecting panel members and implementing the collaborative judgment land process derived from a number of transportation planning sources (AASHTO 2002, AASHTO 2007, TxDOT 2010e).

Many panel members felt the AOI incorporated an unnecessarily large area, stating the majority of future development would not be attributed to improvements to US 281 but rather to other development factors. Although EIS guidance documents encourage overestimation of the indirect effects study area some panel members expressed concern that a "one-size-fits-all" AOI did not sufficiently address the potential natural resource effects of project-related development. In the ensuing discussion, the US 281 EIS Team pointed out that the cumulative effects part of the process (addressed in **Chapter 5 - Cumulative Effects**) provided for larger (in most cases) resource study areas based on the characteristics of each individual resource type, such as surface water, groundwater or ecological resources. Panel member comments were taken into consideration, and the original AOI boundary was revised to reflect a somewhat smaller geographic area, particularly in the northeastern portion of the AOI around Canyon Lake.

4.1.3 Timeframe for the Indirect Effects Analysis

The timeframe for the consideration of indirect effects begins in 2010, the year this analysis was conducted, and extends through 2035, the planning horizon year for *Mobility 2035*. The year is a transportation planning benchmark, providing consistent data and projections for the requirements of the EIS indirect and cumulative effects analysis. 2035 was used by the land use panel as the basis for their land use forecasting as well as the residential absorption analysis described in the cumulative effects analysis in **Chapter 5 - Cumulative Effects**.

4.2 STEP 2: IDENTIFY THE STUDY AREA'S GOALS AND TRENDS

This step describes the general trends and goals of the study area, including community planning goals, demographic trends, and how these goals and trends relate to the sensitivity of the human and natural environment within the AOI.

4.2.1 Goals

The following discussion addresses the plans and goals that have been identified for areas within the AOI by local government agencies and special interest groups through formal planning documents. As stated in NCHRP Report 466, these "Social, economic, and environmental goals…reflect a current vision of the future," that should be compared with changes that could be induced by the proposed project. Possible conflicts between the outlined goals for areas within the AOI and changes induced by each of the Build Alternatives should be assessed and presented in a manner that will further the future resolution, or at least management, of these inconsistencies.

City of San Antonio North Sector Plan

The *City of San Antonio North Sector Plan (North Sector Plan)* was published on August 5, 2010, and encompasses an area of approximately 256,400 acres (approximately 400 square miles) that includes Camp Bullis and Camp Stanley, making the North Sector the largest in the city (COSA 2010a). The plan spans 25 years--from 2010 to 2035--and is framed by the MPO's projection that 735,000 people will live in the North Sector in 2035. The policy goals of the City of San Antonio and the MPO have not been followed up with specific actions by local jurisdictions with land use authority to limit growth north of Loop 1604 or encourage in-fill development.

Compared with *Mobility 2035*, the *North Sector Plan* provides more specific strategies and recommendations concerning future growth, conservation, and redevelopment of physical aspects of the city on a regional level. Some of these specific goals include:

- Constructing road networks to support increased travel demand and encourage connectivity between street design and existing urban street networks;
- Increasing east-west intra-neighborhood collector and local road connectivity, simultaneously reducing north-south arterial traffic;
- Adhering to SmartWaySA (*Long Range Transit Comprehensive Transportation Plan*) recommendations for high capacity transit options;
- Reducing and mitigating flooding hazards by increasing storm water percolation to prevent flash floods within the North Sector's five watersheds;

- Retaining and expanding existing major employers (i.e., South Texas Medical Center, Camp Bullis);
- Recognizing the Edwards Aquifer Recharge and Contributing Zones as the primary potable water source, especially through public education of residential landscaping to reduce runoff;
- Preserving farm and ranch lands.

The *North Sector Plan* employs a strategy based on Centers (i.e., Regional, Specialized, Civic Centers) and Tiers (i.e., Natural, Rural, Urban Core Tiers) to develop land use guidance. Through the Centers and Tiers strategy, it encourages high-density housing only in certain areas (i.e., between Loop 1604 and Loop 410), avoiding highly sensitive natural lands. By encouraging selective high-density development and appropriate land use planning, the plan also focuses on the benefit of mass transit to the North Sector. Finally, the plan addresses the issue of mitigation of development encroachment on Camp Bullis, specifically outlining the necessity for compliance between master development, neighborhood, community, and other plans.

MPO Metropolitan Transportation Plan (MTP) - Mobility 2035

In December 2009, the MPO released *Mobility 2035*, a long-range plan that, in contrast with the *Texas Metropolitan Mobility Plan Update: Breaking the Gridlock* (see below), addresses mobility issues from a fiscally constrained standpoint. The plan is updated every five years, although this is the first time the MPO has involved the public and policy makers in discussion of alternative growth plans for the area. The Transportation Policy Board (TPB) has outlined general goals to aid in developing a regional transportation system that "fosters appropriate land use patterns" and "improves accessibility for traditionally under-served segments of the community" (SA-BC MPO 2009a). This involves attempting to prioritize unfunded transportation projects adopted in *Mobility 2030*, which includes \$2.6 billion in expressway and arterial roadway added capacity projects and \$760 million in interchange projects (SA-BC MPO 2003).

Mobility 2035 is based on a combination of the Transit Oriented Development (TOD) and Infill Development land use scenarios, collectively referred to as TOD + Infill. The combination of these scenarios was selected by a majority of participants at a series of public workshops held by the MPO regarding socio-economic land use scenarios for *Mobility 2035*. Focusing on south central Comal County and north central Bexar County, when compared to the Current Trends scenario (not included in *Mobility 2035*), the TOD + Infill scenario estimates population within the US 281 area to be 33 percent lower, while traffic demand estimates are between 10 and 22 percent lower. TOD + Infill assumes growth will occur in higher densities along major traffic corridors like US 281 and through compact development within the urban core, predicting growth will not exceed the boundaries of Loop 1604 into the Hill Country.

Mobility 2035 also addresses the issue of air quality in San Antonio, stating that as of the document's 2009 publication date, non-attainment of air quality standards was "imminent" while pointing out the city is the first in the nation to sign and complete an Early Action Compact (EAC), also known as The Clean Air Plan. The EAC looks at implementation of alternative modes of transportation and scenario planning through voluntary measures to decrease ground-level ozone and increase air quality (TCEQ 2010c).

However, EPA has determined that as of December 2013, the San Antonio Air Quality Planning Area, which includes Bexar and Comal counties, is in an area designated as in attainment or unclassifiable for all National Ambient Air Quality Standards (NAAQS) under the Clean Air Act.

Other goals of *Mobility 2035* include:

- Support of systematic and coordinated maintenance programs in order to preserve existing facilities;
- Diminishment of growth in single-occupancy vehicles through bicycle and pedestrian facilities, thereby improving air quality;
- Development of a regional transportation system that benefits economic activity, employment growth, and public-private partnerships;
- Development of effective routes and schedules for the public transit system.

The plan attempts to reconcile current and future demands of the population with the existing transportation system in the confines of available funds, which presents a complex and arduous task. Practical strategies, including those mentioned above, aid in promoting a regional transportation system that, "recognizes the uniqueness of San Antonio and ensures respect for neighborhoods, historic and archeological resources, the Edwards Aquifer, and other social and environmental issues" (SA-BC MPO 2009a), and provides an inclusive assessment of the opinions of San Antonio citizens, public agencies, private entities, and other interested parties.

Texas Metropolitan Mobility Plan Update: Breaking the Gridlock

The MPO in conjunction with TxDOT, released the *Texas Metropolitan Mobility Plan Update: Breaking the Gridlock* (TMMP) in January of 2007. In contrast to *Mobility 2035*, the TMMP is a needs-based plan that does not solely focus on funds currently anticipated. Instead, it serves as "a conceptual analysis of transportation needs that provides a menu of options" through which to address major transportation issues seen in each of Texas' eight metropolitan areas (Transportation Management Areas) (TxDOT 2007). The TMMP attempts to identify ways to improve transportation conditions without the fiscal barrier within which *Mobility 2035* operates, allowing for a more comprehensive transportation plan for the San Antonio-Bexar County TMMP study area, which includes all of Bexar County and portions of Comal and Guadalupe Counties.

The TMMP is a long-range plan that aims to reduce congestion to an acceptable level by the year 2030. TxDOT and the Texas Transportation Institute have developed a planning process intended to serve as a statewide initiative to quantify long-range transportation needs in these areas through use of the Texas Congestion Index. For the MPO district, this equates to a total of 2,030 lane mile equivalents. In order to address projected necessity, the TMMP proposes a $7.5 billion plan including rehabilitation of existing facilities, rail relocation, and rapid transit and commuter rail service (i.e., from San Antonio to Austin). The plan acknowledges the necessity for creative, alternative ways to fund these improvements and suggests a range of funding scenarios.

MPO Metropolitan Transportation Plan (MTP) - Mobility 2040

The MPO's Transportation Policy Board adopted *Mobility 2040* on December 8, 2014. The 2040 plan used the same Scenario Planning approach as was used in *Mobility 2035*; however, more current 2010 demographic and land use data and the 2010 transportation network were used to develop projections. In addition, *Mobility 2040* analyzed three growth scenarios: 1) the past 15-year trend would continue, 2) the past 5-year trend would continue, and 3) growth would occur in activity centers/along corridors. On March 24, 2014 the Transportation Policy Board adopted the 5-year trend scenario as its policy to guide growth. It assumes that infill development would occur in Bexar County, which would be medium to high density and would support increased use of alternative modes of transportation. It also assumes growth in Comal, Guadalupe and Kendall counties would continue to follow similar patterns experienced over the last 15 years. *Mobility 2040* acknowledges the groundwork that *Mobility 2035* initiated by adopting the Infill + TOD growth scenario and noted that the adoption of the 5-year trends scenario would to continue to advance these efforts.

Mobility 2040 addresses the issue of air quality in a similar fashion and includes similar goals as *Mobility 2035*. The MPO planning area is currently still in an area designated as being in attainment or unclassifiable for all NAAQS.

Bulverde Comprehensive Plan: Sunrise 2025

The *Bulverde Comprehensive Plan: Sunrise 2025* was released in 2005 as the City of Bulverde's first comprehensive plan (City of Bulverde 2005). The plan aims to establish a "positive, sensible direction" for the city by setting long-term goals regarding management, development, and regulations. City staff, the Steering Committee (stakeholder members), the Mayor, planners, and other community members attempt to identify the unique attractions of Bulverde (e.g., the Hill Country landscape and small town charm) along with less desirable traits (e.g., traffic and suburban growth) to help guide the city in the most successful path toward development.

According to the survey "What Bulverde Should Be," the majority of respondents felt an ideal population for Bulverde would be between 5,000 and 15,000 residents. When asked to evaluate the goals for the comprehensive plan, "protecting and enhancing the environment" and "managing future growth and development" were ranked as most important. Traffic was a major concern too, as well as "retaining community appearance" and the "small town atmosphere." Some citizens also expressed opinions that growth-related problems were caused by the "invading city" by way of US 281 and were concerned about the aesthetic effects of US 281 on the town (City of Bulverde 2005).

The plan is divided into the following categories with specific goals, actions, and objectives outlined for each:

- Infrastructure/Transportation
- Public Safety
- Community Development
- Land Use/Land Development/Growth Management
- Historical/Heritage Preservation
- Economic Development

Since Bulverde is a relatively young town, land use planning and growth management strategies have not been in place for very long. Citizens expressed the opinion that Bulverde's "rural or country atmosphere" as well as the "open spaces, scenery, privacy, and relative proximity [to amenities]" were the most unique characteristics of the town and should be protected through land use planning and growth management (City of Bulverde 2005). The plan identifies subdivision regulations in particular as a key part in managing growth through implementation of new urbanism, traditional neighborhood development, and low-impact development.

In terms of transportation, the plan refers to concurrent planning studies that address schematics of the section of US Highway 281 in Bulverde, right-of-way (ROW) requirements and the need for and location of grade separations (City of Bulverde 2005). The plan also assumes frontage roads along US 281 are planned to extend to the Comal County line (City of Bulverde 2005). Though citizens express distaste for "big city" development near and around Bulverde, access to San Antonio remains "a highly attractive attribute of the Bulverde area" (City of Bulverde 2005).

In order to protect Bulverde's future vision, the plan identifies an extensive list of goals, objectives, and actions along with priority level and identification of responsible entities. The plan maintains that, when necessary, appropriate updates will be incorporated. As of 2011, the plan is the only comprehensive planning document available for the City of Bulverde.

Comal County Thoroughfare Plan

As seen in the revision to the *Comal County Major Thoroughfare Plan* map on August 5, 2010, the Comal County Engineer's Office depicts US 281 as a freeway that continues northward from the Comal County line terminating at the Guadalupe River (Comal County Engineer's Office 2010).

Camp Bullis Joint Land Use Study

The *Camp Bullis Joint Land Use Study* (JLUS), finalized in June 2009, offers recommendations regarding avoidance of the consequences of incompatible development of the Camp Bullis military installation and the surrounding areas (City of San Antonio et al. 2009). The plan stresses the interdependency of the installation and the community, attempting to facilitate joint planning to protect the military mission as well as the health of the economy and industries of the community.

The plan addresses growth in the immediate future through the next 50 years in Bexar, Comal, and Kendall Counties. While 24 compatibility factors are used to characterize local issues specific to Camp Bullis and the surrounding communities, the JLUS focuses on six critical compatibility/encroachment issues that must be addressed in order to protect the current and future goals of the installation as well as the safety of these communities. Those issues are:

- Land use
- Light
- Noise
- Vertical obstructions and safety
- Threatened and endangered species
- Water

Through implementation of preventative measures regarding these key issues, the Camp Bullis JLUS encourages collaborative development of land use guidelines with other interested parties. It attempts to resolve negative impacts that, in the wake of impending development, could result in irreversible damage to economies, industries, environments, and overall quality of life for communities around Camp Bullis and within the AOI.

Facts & Issues: Land-Use Planning in Comal County "A Growing Problem"

The League of Women Voters of Comal Area (LWV-CA) published *Facts & Issues: Land-Use Planning in Comal County "A Growing Problem"* in 2005 in an effort to "create interest in further dialogue in Comal County about [land use] planning" (LWV-CA 2005). The report summarizes the findings of a series of public meetings held in 2003 and 2004 that included interviews with Comal County, New Braunfels, and Bulverde elected officials and staff, environmental experts, developers, and a planning consultant.

According to the plan, the substantive growth seen between 1990 and 2000 is expected to continue as a result of the area's proximity to San Antonio and Austin as well as economic trends, demographic shifts, and an influx of native and immigrant populations. Along with this growth come substantial effects on key resources and alteration of quality of life for residents as urbanization spreads throughout Comal County.

The findings of the public meetings are separated into five key issues:

- Water quality in Comal County
- Air quality in Comal/Guadalupe/Bexar/Wilson County region
- Transportation in Comal County
- Residential development/parks/natural areas
- City—County relations (LWV-CA 2005)

In terms of water quality and quantity, the document states "conflicting regulatory systems" have resulted from separating water issues into human consumption and agriculture functions versus wildlife, industry, and recreation functions (LWV-CA 2005). The document also points out the lack of regulation of the Trinity Aquifer in comparison to the Texas Commission on Environmental Quality's (TCEQ) regulation of the Edwards Aquifer Recharge Zone. In terms of surface water, the document states regulatory agencies such as the San Antonio River Authority (SARA), the Guadalupe-Blanco River Authority (GBRA), and local water purveyors attempt to manage the growing demand on the two major rivers within the area and Canyon Lake. Due to the "lack of coordination and communication among the myriad of entities with some control over water" (LWV-CA 2005), water demands will likely surpass the supply in the wake of population increases, and "limited water resources will continue to be one of the important problems for local governments to solve" (LWV-CA 2005).

Air quality issues within the area are handled by the Air Improvement Resources Committee (AIRCO), an entity of the Alamo Area Council of Governments (AACOG). Specifically, the document suggests that mixed use developments would increase alternative transportation opportunities, resulting in decreased adverse effects on air quality. Furthermore, alternative transportation solutions beyond road widening that could improve mobility (and, in turn, air quality) within the area include passenger rail connection and encouragement of ART bus usage through regular scheduling and park-and-ride locations.

The document cites conservation developments and Green-Belt Zoning as possible alternatives to conventional development with the Comal County area. It also points out that the cities of "New Braunfels, San Antonio, and Bulverde are the most important areas involving land use policy" within the Comal County area, further stating that "cities have greater legislative ability to control growth and ameliorate its effect on air and water quality" (LWV-CA 2005). Finally, the document states the population growth expected in the area "will surely tax both existing land and water resources and stretch present city and county services…beyond their ability to respond" (LWV-CA 2005), further stressing the criticality of improved city—county communication.

Edwards Aquifer Authority Strategic Plan 2014-2016

The *Edwards Aquifer Authority Strategic Plan 2014-2016 (Strategic Plan)* was adopted on December 10, 2013 (Edwards Aquifer Authority 2013a). The Edwards Aquifer Authority (EAA) was created in 1993 by the Texas Legislature to preserve and protect the aquifer; it began operating in 1996. As a political subdivision of the State of Texas, it is subject to legislative oversight and is composed of 15 elected members from the region and two non-voting appointed members. The EAA is responsible for water quantity, quality, and support of the Edwards Aquifer, the main water resource for south central Texas. The EAA's region encompasses eight counties, including: Uvalde, Medina, and Bexar Counties in their entireties, as well as portions of Atascosa, Caldwell, Guadalupe, Comal, and Hays counties.

The *Strategic Plan* is updated annually and covers a span of three years, from 2014 to 2016. In anticipation of the region's population growth, the EAA has outlined the strategic goals for the next three years, listing action steps, tasks, and responsible parties for each goal. These include:

Aquifer Management and Protection

- Goal A: Sustain Federally Protected Aquifer-Dependent Species
- Goal B: Manage Groundwater Withdrawals
- Goal C: Develop Recharge Program for Improved Aquifer Management and Springflow Maintenance
- Goal D: Prevent the Pollution of the Aquifer

Organizational Effectiveness

- Goal E: Conduct Research that Enhances Understanding and Effective Management of the Aquifer
- Goal F: Develop a Diverse, Service-Oriented Organization
- Goal G: Build Shared Value in the EAA Mission
- Goal H: Sustain Fiscal Stability

Based on these goals, the EAA intends to implement the action steps and tasks necessary to ensure continued health of the aquifer. Some of the action steps specified include: collaborative approach with area regulatory agencies; assessment of the effectiveness of groundwater withdrawal permits; and implementation of a groundwater recharge program. Action items re-listed for each year of the plan include: continuing ecosystem and bio-monitoring at Comal and San Marcos Springs; continuing to improve the ease, efficiency, and accuracy of meter readings for all permit holders; and continuing to maintain a Critical Period Management Plan consistent with criteria set forth in the Edwards Aquifer Authority Act.

Edwards Aquifer Recovery Implementation Program

The Edwards Aquifer Recovery Implementation Program (EARIP) is a voluntary, multi-stakeholder program aiming to protect federally-listed endangered species while addressing current and future development and water demand with respect to the Edwards Aquifer.

The Edwards Aquifer extends from Kinney County in the west to Bexar County in the east and up into Travis County. It is the primary source for drinking water for two million people in south central Texas and is used for agricultural, municipal, industrial, and recreational purposes. It is also the source for San Marcos and Comal Springs, the only remaining major springs in the state (TAMU 2010a). These springs are home to the federally-listed species the EARIP aims to protect and rely heavily on the continued health of the aquifer in order to maintain spring flow. The primary threat to these endangered species occurs when this spring flow is reduced, resulting in loss of viable habitat for vulnerable species.

According to the EARIP, eight species dependent on the Edwards Aquifer system are endangered and include: the fountain darter *(Etheostoma fonticola),* San Marcos salamander *(Eurycea nana),* San Marcos gambusia *(Gambusia georgei)*, Texas blind salamander *(Eurycea rathbuni)*, Peck's cave amphipod *(Stygobromus pecki)*, Comal Springs dryopid beetle *(Stygoparnus comalensis),* Comal Springs riffle beetle *(Heterelmis comalensis)*, and Texas wild rice *(Zizania texana).*

In accordance with the Texas Legislature order issued in May 2007, the Edwards Aquifer Authority and other state and municipal water agencies participated in the EARIP and completed a plan for the endangered species dependent on the Edwards Aquifer. This Habitat Conservation Plan for the Edwards Aquifer (EAHCP) outlines a two-phase implementation strategy, the first phase of which commenced on March 18, 2013, and involves habitat and springflow protection measures.

2011 South Central Texas Regional Water Plan

The *2011 South Central Texas Regional Water Plan* (SCTRWP) includes population and water demand projections as well as management strategies and recommendations for Region L of the state-wide regional water planning process established by the Texas legislature in 1997. It incorporates 21 counties in south central Texas, three of which, Bexar, Comal, and Kendall counties, are within the US 281 AOI. The plan is organized according to Texas Water Development Board (TWDB) guidelines and will be included in the State Water Plan to be issued in 2012, along with 15 other regional water plans. The San Antonio River Authority (SARA) serves as the administrative agency for the Region L Plan to aid in scoping, grant application, contractual agreements, and management of plan development. The plan is currently scheduled for review by the TWDB for Fall/Winter 2010.

The planning period for the SCTRWP extends to 2060, at which time it projects that approximately 4.3 million persons will reside in the South Central Texas Region. Sixty-eight percent of these residents are expected to live within the San Antonio River Basin alone. Region L encompasses five major and three minor aquifers, two of which are included within the US 281 AOI: the Edwards and Trinity Aquifers.

Of the 21 counties within Region L, 14 have been identified as areas with water shortages. The region is expected to suffer economically as a result; a total of $5.28 billion per year in lost production as a result of projected water shortages is estimated for the region in 2020.

The SCTRWP identifies a number of water management strategies that, if employed, could produce in excess of 755,000 acre feet per year in new supplies in 2060. Strategies emphasizing conservation include:

- Municipal water conservation
- Irrigation water conservation
- Drought management
- Mining water conservation

Other recommended management strategies of the SCTRWP include the following, along with selected projects through which to implement those strategies.

- Maximize the use of available resources, water rights, and reservoirs
    - Edwards transfers
    - GBRA-Exelon project
- Simultaneously develop groundwater supplies and limit depletion of storage in regional aquifers
    - Brackish Wilcox groundwater for San Antonio Water Systems (SAWS)
    - GBRA Simsboro project
- Engage the efficiency of conjunctive use of surface and groundwater as well as maximize the *use* of available resources and water rights
    - LCRA-SAWS water project
    - Edwards Aquifer recharge
- Involve new surface water appropriations while avoiding development of large mainstem reservoirs
    - GBRA Mid-Basin project (surface water)
    - storage above Canyon Reservoir

The plan also includes Recycled Water Programs as a water management strategy as well as development of brackish groundwater desalination. These strategies, along with others currently under study, are intended to meet the projected water supply needs or shortages for "municipal, industrial, steam-electric, and mining uses" (SCTRWPG 2010). As part of the required Infrastructure Financing Report (IFR), Region L must examine the necessary funding for the strategies and projects within the SCTRWP. According to survey responses from wholesale water providers and municipal water groups, funding for the $6.7 billion strategies and projects would be sought through the Texas Water Development Board's Water Infrastructure Fund (WIF), WIF-Deferred Program, WIF-Construction Program, and State Participation Program. Remaining funds could come from bonds, private funding, or local cash reserves.

Cow Creek Groundwater Conservation District Groundwater Management Plan

The *Cow Creek Groundwater Conservation District* (CCGCD) *Groundwater Management Plan* (GMP) was originally adopted in 2004 and revised in 2009 (Cow Creek GCD 2009). The GMP covers a planning period of 50 years and is reevaluated every five years. In 1990, the Texas Hill Country Area (now the Hill Country Priority Groundwater Management Area), which incorporates CCGCD, was declared a Critical Groundwater Area by the TWDB, notifying residents that water availability and quality will be at risk by 2015. The CCGCD aims to identify groundwater management techniques and strategies to locally address groundwater issues within the District.

The District encompasses all of Kendall County with the exception of the City of Fair Oaks Ranch. Since its inception in 2002, the District has been funded by property taxes and fees and governed by five elected directors. It is included in the South Central Texas Regional Water Planning Group (Region L). The CCGCD area is characterized as a rural area that includes some bedroom communities linked to San Antonio by Interstate 10, and US 281 and includes Boerne and the townships of Sisterdale, Kendalia, and others. In recent decades, rapid growth has led to fragmentation of land into smaller tracts more suitable for suburban development.

The CCGCD is underlain by the Trinity and Edwards Group, which serve as the major sources of water for the area. The Trinity is primarily recharged by local precipitation on its outcrop and through the fracturing and porosity of overlying units; the Edwards Group is recharged solely from local precipitation.

In order to prevent the necessity for complete allocation and attempt to stabilize growing water demands, CCGCD has identified the following goals:

- Implement management strategies that will provide for the most efficient use of groundwater;
- Implement strategies that will control and prevent waste of groundwater;
- Implement strategies that will control and prevent subsidence;
- Implement management strategies that will address conjunctive surface water management issues;
- Implement strategies that will address natural resource issues which impact the use and availability of groundwater, or which are impacted by the use of groundwater;
- Implement strategies that will address drought conditions;
- Implement strategies to address conservation, recharge enhancement, rainwater harvesting, precipitation enhancement, and brush control;
- Address desired future conditions in a quantitative manner (Cow Creek GCD 2009).

By 2060, the CCGCD is expected to see a water demand increase from 7,313 acre feet per year to 17,984 acre feet per year, which equates to a 146 percent increase over approximately 50 years. Continuing development is unevenly dispersed throughout the area, with the majority of growth occurring at the southern end of the county over the Trinity Aquifer; however, low-yield wells and water quality concerns make the aquifer unsuitable to sustain such development. The goals outlined by the CCGCDGMP are intended to deal with the immediate need for water management as development continues to spread throughout south central Texas.

Southern Edwards Plateau Habitat Conservation Plan

According to the *Southern Edwards Plateau Habitat Conservation Plan* (SEP-HCP) website, Bexar County, the City of San Antonio, and other partners are in the process of developing an HCP to ensure the needs of the Southern Edwards Plateau community and natural environment are met in a manner compliant with the Endangered Species Act (ESA), National Environmental Policy Act (NEPA), and Chapter 83 of the Texas Parks and Wildlife Code (see www.sephcp.com). The SEP-HCP website identifies a projected date for receipt of an incidental take permit in 2013. This plan will allow for local control and a simplified process for complying with the ESA in an attempt to balance conservation needs of rare species with the demand for economic growth and development seen throughout south central Texas. The plan will also include a regional conservation program designed to protect sensitive natural resources in south central Texas. The planning period for the SEP-HCP is 30 years, which coincides with the duration of an incidental take permit.

The SEP-HCP planning area includes Bexar, Medina, Bandera, Kerr, Kendall, Blanco, and Comal Counties. According to the SEP-HCP website, “endangered species conservation in south central Texas has become a priority and has spurred Bexar County and the City of San Antonio to seek better ways of encouraging ESA compliance and protecting the area’s endangered species.” The Draft Provisional List of Species to be addressed in the SEP-HCP (June 10, 2010) lists five species to be covered by the incidental take permit; specifically, the golden-cheeked warbler (GCWA) (*Dendroica* *chrysoparia*), black-capped vireo (BCVI) *(Vireo atricapilla),* two ground beetles (*Rhadine exilis* and *Rhadine infernalis*) and the Madla Cave meshweaver (Circurina madla). It also lists six future covered (i.e., anticipated listing) species, seven voluntarily conserved species, ten additional species that would benefit from the conservation actions but for which no measures would be included, and a section addressing three mussels and the treatment of other aquatic species.

A recent draft document by the Biological Advisory Team (BAT) outlining the General Conservation Strategies for the plan was approved by the Citizens Advisory Committee (CAC) on September 13, 2010. It establishes several broad community-based goals and objectives of the conservation program, including regional conservation, support of Camp Bullis, stakeholder involvement, streamlined permitting, locally appropriate and cost-effective implementation, and leveraging of resources. Bexar County is leading the SEP-HCP production, although the CAC, BAT, Agency Oversight Group (AOG), and consultant team all aid in overall development, coordination, and review of the plan.

Bexar County Karst Invertebrates Recovery Plan

The *Bexar County Karst Invertebrates Recovery Plan* (BCKIRP) was released by the US Fish and Wildlife Service (USFWS) in August 2011. As of 2000, nine endangered karst invertebrates were located within Bexar County: *Rhadine exilis, Rhadine infernalis, Batrisodes venyivi, Texella cokendolpheri, Neoleptoneta micros, Circurina baronia, Circurina madla, Circurina madla, Circurina venii,* and *Circurina vespera*. These species are listed as 2C recovery priority, and critical habitat for each was designated in 2003 with the exception of the Government Canyon Bat Cave spider and meshweaver. The draft plan aims for delisting of each of the species, with projected down-listing in 10 years and delisting in 25 years.

Though all nine of the species are troglobites (underground-dwelling), the surface environment heavily influences the health of the invertebrates. Alteration of cave and mesocavernous voids in karst limestone threatens stability of these animals and commonly occurs as a result of suburban development and rock quarrying. The BCKIRP specifically lists habitat degradation activities as: "altering drainage patterns, altering native surface plant and animal communities, reducing or increasing nutrient flow, contamination, excessive human visitation, and competition and predation from non-native, invasive species" (USFWS 2011).

The BCKIRP identified several actions needed to achieve delisting for each of the nine endangered karst invertebrates within Bexar County:

1. Delineate and protect areas needed to meet recovery criteria
2. Perform additional research
3. Education
4. Establish post-delisting monitoring
5. Monitoring

In order for these nine species to be delisted, adequate cave quantity and quality must be secured; cave and cave cluster, drainage basin, and surface community preservation is critical. Despite their location underground, above-ground activities directly affect the health and stability of these species. Recovery will also require a further understanding of population dynamics and habitat requirements and incorporation of further research into adaptive management actions (USFWS 2011).

Comal County Regional Habitat Conservation Plan

The *Comal County Regional Habitat Conservation Plan* (CCRHCP) was released in April of 2009 with a planning period of 30 years (Comal County 2009). The plan seeks an incidental take permit for Comal County through which landowners can comply with the ESA without applying for an individual permit, reducing cost and application time. According to the plan, the population in Comal County is expected to grow to 234,257 people by 2039, an increase of 107 percent from 2009. In order to better serve residents, conserve available resources, and protect and preserve threatened and endangered species, implementation of the CCRHCP is recommended by the Comal County Commissioners Court in preparation for projected urbanization.

The CCRHCP includes two covered species: the GCWA and the BCVI, both of which are currently listed as endangered. Approximately 65,581 square acres of native woodlands suitable for GCWA habitat are found within Comal County, while less than 1,000 square acres of semi-open scrubland suitable for BCVI habitat are found within the area. Nine additional species, referred to as evaluation species, are addressed in the plan on the basis of listing potential but will not be included in the permit.

The primary purpose of the CCRHCP will be addressed through the following actions:

1. Contribute to and facilitate the conservation of the covered species while preserving open space in the county
2. Help conserve and obtain information about the evaluation species thereby assisting the Service in precluding the need to list them
3. Provide the affected landowners of Comal County a more efficient process for complying with the ESA compared to individual permitting and consultation processes with the Service (Comal County 2009)

Participation in the CCRHCP is voluntary and is estimated to occur at a rate of 20-50 percent of landowners within the county. Income for the plan will be generated through GCWA conservation credits; BCVI mitigation actions will be determined at a later date.

Black-capped Vireo Recovery Plan

The USFWS issued the *Black-capped Vireo (Vireo atricapillus) Recovery Plan* (BCVRP) in 1991 with intent of downlisting by 2020 (USFWS 1991). The plan indicates a 2C recovery priority for the vireo and identifies strategies to stabilize and protect the species.

The BCVI region occurs in deciduous-evergreen shrubland in Oklahoma, Texas, and Mexico; populations previously existing in Kansas have been extirpated. As of 1991, though the number of vireos in Oklahoma was below 300, populations in Texas were present in a number of localities, specifically the Lampasas Cut Plains, Edwards Plateau, and along the Balcones Escarpment. According to the plan, deterioration of the Texas populations of the BCVI "may be extensive, particularly from north-central Texas and south, to the San Antonio (Bexar County) Region" (USFWS 1991). Populations in Coahuila, Mexico, are of unknown status. Major threats to the species include habitat loss through development, pesticides, direct human disturbances, and cowbird nest parasitism.

Actions for down-listing of the species are listed as follows:

1. Additional surveys
2. Clarify population size, area requirements, and location needs for viable populations

3. Maintain viable populations in target areas
4. Conduct research on species' biology, habitat needs and management, threats, and winter range
5. Eliminate threats from cowbird nest parasitism, habitat deterioration and other agents
6. Develop and conduct a program for monitoring the vireo's status (USFWS 1991)

As development spreads in the BCVI range, populations are continually threatened. Down-listing will be achieved when one breeding population exists in all six BCVI regions (one in Oklahoma, one in Mexico, and four in Texas); sufficient and sustainable areas exist to support their winter range; and when the former requirements occur for at least five continuous years and continue to be maintained. As of 2011, the BCVI is still an endangered species.

Golden-cheeked Warbler Recovery Plan

The *Golden-cheeked Warbler (Setophaga chysoparia) Recovery Plan* (GCWRP) was issued in 1992 by the USFWS. The species was listed as endangered in February of 1991 as a 2C recovery priority (indicating a high degree of threat), though habitat degradation has occurred since at least 1962 (USFWS 1992).

According to the GCWRP, threats to the species include clearing of mixed evergreen-deciduous woodlands (especially Ashe juniper) with moderate to high canopy cover, anthropod prey, water scarcity, and nest parasitism and predation. The warbler winters in northern Mexico and southern South America in the pine-oak woodlands but spends the breeding season in the mixed evergreen-deciduous woodlands of Central Texas. Specifically, the Balcones Escarpment serves as prime warbler habitat (USFWS 1992).

Actions for achieving delisting for the warbler are outlined by the plan as follows:

- Studies of GCWA population status and biology, ecology, habitat requirements, and threats on breeding grounds and in winter range along their migration corridor;
- Protection of existing populations and habitat in the breeding range, wintering range, and along the migration corridor;
- Increased voluntary protection of warbler habitat;
- Enhancement and maintenance of the quality of warbler habitat on public and private lands;
- Increased public awareness of the importance of the species and other endangered species;
- Regulatory protection (USFWS 1992).

Specific criteria must be met in order for a species to be considered for delisting. The following criteria for the eight regions of breeding habitat for the GCWA are outlined in the GCWRP as follows:

- Sufficient breeding habitat has been protected to ensure the continued existence of at least one viable, self-sustaining population in each of the eight regions outlined in the plan;
- The potential for gene flow exists across regions between demographically self-sustaining populations where needed for long-term viability
- Sufficient and sustainable non-breeding habitat exists to support the breeding populations;
- All existing GCWA populations on public lands are protected and managed to

ensure their continued existence;
- All of these criteria have been met for 10 consecutive years (USFWS 1992).

Furthermore, recommendation issuing from the "Population and Habitat Viability Workshop" held by USFWS in 1995 was to protect sufficient habitat for a carrying capacity of 3,000 breeding pairs for each of the eight GCWA recovery regions. Specific habitat measures recommended include prevention of habitat damage by herbivores, habitat restoration, maintenance of high-percent canopy cover of trees, prevention of oak wilt, control of predator and nest parasites, limitations of human impacts in habitat, and implementation of landscape-level planning (USFWS 1996).

Rapid suburban development in Central Texas continues to threaten GCWA habitat, especially along the Austin-San Antonio corridor. In the Draft Resource Assessment for the warbler for the SEP-HCP Plan Area by Loomis Partners (2010), Recovery Region 6 (which overlaps the AOI) could require permanent protection and management of around 75,000 acres of relatively high-quality GCWA habitat; despite these efforts, the warbler is still an endangered species as of 2011.

4.2.2 Trends within the AOI

Population trends 1970-2010

US Census information from 1970 to 2010 was reviewed to determine past trends in population growth in the US 281 Study Area (US Census Bureau 1970, 1980, 1990, 2000c, 2010b). All the cities and counties reviewed showed steady growth over the 40-year period, as shown in **Table 4-2**. Bexar County grew by 106 percent over the period, while Blanco County grew by 194 percent. Comal County grew by 349 percent and Kendall County by 380 percent. The Cities of Blanco, New Braunfels and Boerne are just outside the AOI; their population data are shown to reflect the longer term urban trends in the general area of the Texas Hill Country.

Table 4-2: Population Trends for Selected Cities and Counties 1970-2010

	Pop. 1970	Pop. 1980	Pop. 1990	Pop. 2000	Pop. 2010
County					
Bexar	830,460	988,800	1,185,394	1,392,931	1,714,773
Blanco	3,567	4,681	5,972	8,418	10,497
Comal	24,165	36,446	51,832	78,021	108,472
Kendall	6,964	10,635	14,589	23,743	33,410
City					
New Braunfels	17,859	22,402	27,334	36,494	57,740
Blanco	No data	1,179	1,238	1,505	1,739
Boerne	2,400	3,254	4,274	6,178	10,471

Source: US Census Bureau, 1970, 1980, 1990, 2000, 2010.

New Braunfels grew by 223 percent, while Boerne grew by 336 percent. Over the more recent period from 2000 to 2010, Kendall was the fastest growing county with a 41-percent increase over the decade. Boerne was the fastest growing city with a growth rate of 69 percent for the same period (**Appendix G**). These growth rates are relatively high for such areas in Texas and are indicative of the continuing suburbanization effects in the areas around San Antonio, especially along major arterials such as US 281 and IH-35.

The population counts from the US Census indicate continued growth in the San Antonio area. The 2012 population estimate for the City of San Antonio was 1,382,951, making it the second-most populous city in Texas, as well as the seventh-most populous city in the US. The 2012 US Census count for the eight-county San Antonio–New Braunfels metropolitan area placed its population at 2,234,003, making it the third-most populous metropolitan area in Texas and the 25th-most populous metropolitan area in the US. The metropolitan area is bordered to the northeast along IH-35 by the Austin–Round Rock–San Marcos Metropolitan Statistical Area (MSA), and the two metropolitan areas together combine to form a region of almost 3.9 million people. San Antonio was the third-fastest-growing large city in the nation from 2000 to 2010.

Population Growth Projections 2000-2035

Table 4-3 summarizes recent and projected population growth for the four county area (Bexar, Comal, Kendall and Blanco counties) developed by the Texas State Data Center and Environmental Systems Research Institute (ESRI) from 2000 through 2035. Also shown is recent and projected growth for the same period for the AOI based on the residential housing sector analysis. The average annual growth rates within the AOI of 6.4 percent per year characterized a rapid growth trend from 2000 to 2009, mostly in Bexar County sectors of the AOI. This population growth rate within the AOI is projected to taper off slightly to an annual average of 5.5 percent from 2010 to 2035, still far exceeding the four-county annual average growth rates, which range from 1.2 percent to 1.9 percent under various growth scenarios. The population of the AOI is expected to grow by 351,321 people between 2010 and 2035, reaching a total population of 596,227, which would be 22 percent to 27 percent of the four-county population as predicted under the various growth scenarios. See **Appendix M** for a detailed table of the population projections of the four counties intersecting the AOI and projected population growth within the boundaries of the AOI.

Table 4-3: Population Projections for 4-County Area and the US 281 AOI Residential Housing Sectors 2000-2035

Scenario/Sector	Region/ County	2000	2009	2020	2030	2035	Annual % Change 2000-2009	Annual % Change 2010-2035	Avg. Annual Change 2000-2009	Avg. Annual Change 2010-2035	Total Population Change 2010-2035
TSDC 0.5	Total Pop. (Bexar, Blanco, Comal and Kendall counties)	1,503,113	1,681,370	1,897,131	2,097,864	2,197,906	1.3%	1.2%	19,806	19,867	516,536
TSDC 2.0	Total Pop. (Bexar, Blanco, Comal and Kendall counties)	1,503,113	1,734,230	2,017,004	2,229,590	2,410,366	1.7%	1.5%	25,680	26,005	676,136
ESRI BIS	Total Pop. (Bexar, Blanco, Comal and Kendall counties)	1,503,113	1,804,323	2,181,074	2,529,503	2,702,804	2.2%	1.9%	33,468	34,557	898,481
	US 281 AOI	154,922	244,906	377,718	522,509	596,227	6.4%	5.5%	9,998	13,512	351,321

Sources: Texas State Data Center (TSDC) - County Population projections five scenarios based on assumed migration rates. Environmental Systems Research Institute Business Information Solutions (ESRI BIS) - projections by census tract aggregated to sector analysis and projections by SA Research Corporation, 2010.

Independent school districts (ISDs) within the AOI have had to plan and develop facilities in accordance with the past rapid growth trend and projected future growth. In particular, the Comal ISD primarily serves the AOI's highest future growth areas, whereas the other independent school districts within the AOI, such as the North East ISD and the Northside ISD, serve areas that are already highly developed. The Comal ISD projects the student population to increase by 55 percent, or 9,153 additional students, between January 2010 and the 2019/2020 school year, based on projections provided by the ISD (Comal ISD 2010).

Land Development

Land development trends over the past three decades have substantially changed the land use characteristics of the AOI. **Figure 4-3** depicts the historical transformation of land uses in many areas of the AOI from farming, ranching, or undeveloped uses to residential subdivisions, commercial, transportation, and other developed uses over the period 1983 to 2008. The map was prepared through analysis of aerial photography from the following sources:

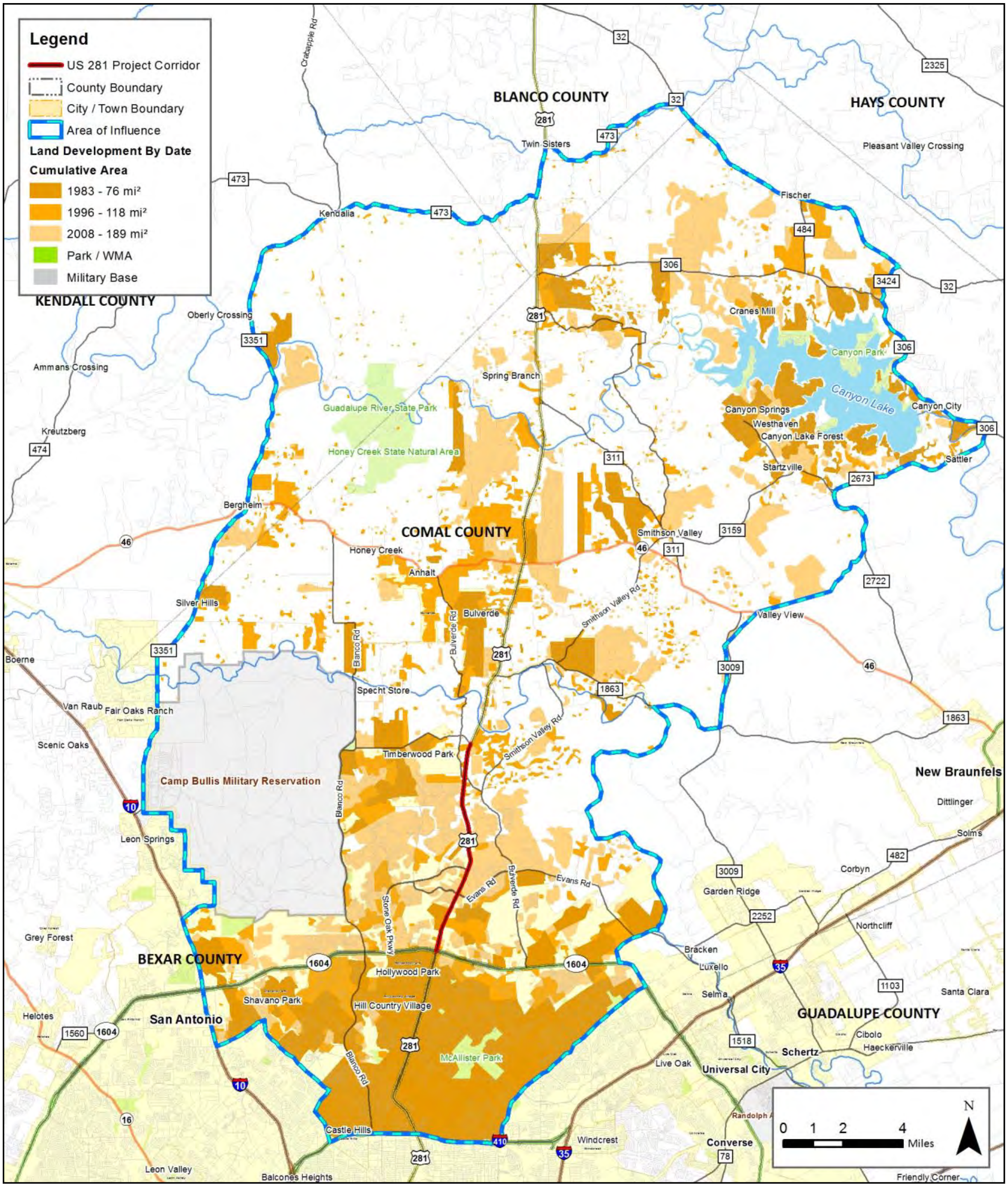
- 1983 National High Altitude Photography Program (NHAP). The process involved georeferencing and rectifying the photography to StratMap road layers and 2008 NAIP photography. Source: US Geological Survey (USGS).
- 1996 Texas OrthoImagery Program (TOP) Digital Ortho Quarter Quads (DOQQs). Source: Texas Natural Resources Information System (TNRIS).
- 2008 National Agricultural Imagery Program (NAIP) Aerials. Source: US Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS).

In order to give a context for historical, current and future land development within the AOI, the years 1983-2008 are defined as past development, the years 2008-2015 defines current development, and the years 2015-2035 are defined as future development. The year 2015 is the construction year for the anticipated Preferred Expressway Alternative. The developed area polygons shown in varying shades on **Figure 4-3** depict the sequence of development in the AOI in approximately 12-13 year intervals. The figure also indicates the prominence of development during the most recent period (1996-2008) in the corridor immediately adjacent to the proposed US 281 project limits, from Loop 1604 to Borgfeld Drive. Further development in this area has occurred since 2008.

The pace of recent development in the AOI reflects a pattern of increasing suburban land use throughout the southern Texas Hill County region. The historically rural and under-developed Hill Country has seen increased growth over the past several decades as the cities of San Antonio, New Braunfels, and Boerne have increased in population. Some cities, such as Kerrville, have grown so quickly that local residents coined the term "Kerrville Syndrome" to describe the rapid loss of pasture, field, and grazing land to commercial and residential development throughout the Hill Country (Lyon 1983). Within the AOI, most development has occurred in the southern portion, directly north of San Antonio in the immediate vicinity of the project area on US 281. Recent major developments in this area include PGA Village, comprising the 36-hole TPC San Antonio golf course and adjoining JW Marriott San Antonio Hill Country Resort and Spa, and the 2,800-acre Cibolo Canyons residential development.

Other major land developments recently completed or expanded in the AOI include Steubing Ranch, Mystic Shores, and Bulverde Oaks. This area has seen significant suburban commercial and residential development in the form of shopping centers along Loop 1604 and upscale residential neighborhoods along US 281. North of Cibolo Creek, development has been somewhat more limited, although some residential neighborhoods have been developed especially on the south side of the Guadalupe River on both sides of US 281, and on the hills surrounding Canyon Lake.

1 Figure 4-3: Historical land development trends in the AOI: 1983, 1996, 2008



2

3 Source: US 281 EIS Team, 2010

In the majority of developed areas, new construction has focused on hillsides and valleys, locations where the land was previously unused or fenced off for pasture. With the focus of sheep and goat ranching shifting more toward the Edwards Plateau, this land is slowly being sold for development. Despite this loss of pasture lands, other rural areas of the Hill Country remain decidedly agricultural. The river and creek valleys retain cultivated fields, with little or no development occurring along them. Road building has likewise focused predominantly in the hills, providing access to and within the various residential subdivisions.

Trends in the Development of Agricultural Lands and Open Space

The land resource fundamentally contributes to most other environmental resource categories in the indirect and cumulative effects analyses. Land provides the loci for terrestrial habitat of animal and plant species. Land development, or changes in land use, is the driving variable in evaluating potential impacts to ecological conditions, water quality and supply, community and socioeconomic resources, and historic and archeological resources.

An important land resource trend involves the relationship between land development and agricultural use and soil productivity, as well as open space and the visual environment. Agricultural land uses are declining in the AOI. Given the prominence of rangeland among all agricultural uses in the area, it may be assumed that land conversion to suburban residential uses is largely equivalent to a loss of rangeland or open space. The trends seen in the AOI are consistent with statewide and regional trends in loss of agricultural lands in high growth areas of Texas, as reported by the Texas A&M Institute of Renewable Natural Resources (Wilkins et al. 2009). One notable trend that illustrates the fragmentation of agricultural lands is that the amount of land in mid-sized farms and ranches along the IH-35 corridor has declined at the rate of about 14,000 acres per year from 1997 to 2007. There has been an increase in the total number of farms and ranches in the region, yet a decline in the agricultural land base of up to 14 percent in the IH-35 corridor, reflected in a 21 percent decline in average ownership size.

After many years of decline, agricultural land use and productivity have stabilized in Bexar and Comal counties and are showing signs of decline in Kendall and Blanco counties. The photo-analysis of historical land development on **Figure 4-3** supports this assessment, showing the Bexar county portion of the AOI to be almost completely developed and the Comal County portion increasingly developed over the 1983-2008 period of analysis. The data showing agricultural/land conversion would support a similar conclusion about a decline or at least a substantial transformation in the visual environment, with publicly-accessible viewsheds transformed from rangeland to residential and mixed use development in many locations in the southern portion of the AOI.

Natural Resource Trends

Water Quality

Water resources trends within the AOI vary according to the overall land use and development trends within their watersheds and also according to site-specific influences. To some extent these trends are evident from the Statewide Water Quality Assessments and listings of impaired waters prepared by the TCEQ. There is a general trend towards declining stream health and more pervasive water quality and aquatic habitat degradation in the more heavily developed (north San Antonio) portions of the

AOI. This is evidenced by the listings of impaired segments of Salado Creek, the upper San Antonio River headwaters, and Mid-Cibolo Creek over the past several assessment cycles for such water quality parameters as bacteria, depressed dissolved oxygen and impaired macrobenthic (aquatic insect) communities and impaired fish communities.

In the northern parts of the AOI, the upper Guadalupe River, Canyon Lake, and the Blanco River tributaries are relatively less affected by land development and have high quality waters and aquatic ecosystems, except in localized cases of degradation. For example, the Guadalupe River above Canyon Lake (Segment 1806) is listed on the 2012 303(d) List for bacterial contamination. This segment was first listed as impaired in 2002.

Canyon Lake has historically been one of the clearest and cleanest reservoirs in Texas. However, the last several reservoir assessments conducted by the TCEQ indicate a trend towards eutrophication, or nutrient enrichment, as measured by indicators of algal biomass and other measures.

The Edwards Aquifer is known for its abundant clean and high quality water. Results from the well and spring water quality sampling program of the EAA (2009b) generally confirm that water quality remains high. However, the Aquifer remains vulnerable to water quality degradation.

Threatened and Endangered Species

Given state and federal listing as threatened and endangered species, the listed mussels, terrestrial karst invertebrates, aquifer species, reptiles and birds evaluated in this analysis are associated with downward trends over the last 25-30 years. This downward trend probably began when the Central Texas human population began to expand and more intensive agricultural practices were adopted. Generally, habitat impacts (deteriorating water quality and vegetation clearing for example) have been the leading causes of this decline.

4.3 STEP 3: INVENTORY THE STUDY AREA'S NOTABLE FEATURES

Agency guidance documents (TxDOT 2010; NCHRP 2002) define the term "notable features" as specific valued, sensitive, vulnerable, or unique elements of the environment. These include sensitive species and habitats, unique or distinctive landscape features, and valued environmental components or "attributes of the environment that society seeks to use, protect, or enhance" (Irwin and Rodes 1990, quoted in NCHRP 2002). The data gathering and environmental constraints analysis performed for the direct effects assessment (see **Chapter 3 - Affected Environment and Environmental Consequences**) identified a number of environmental components that are considered unique, valued or vulnerable. For the Indirect Impacts analysis, these components are analyzed in the larger context of the AOI and prioritized according to factors such as intrinsic value, uniqueness, vulnerability or threat. Notable features are identified in the following resource and/or feature categories: (1) land; (2) socioeconomic; (3) air quality; (4) water; (5) ecological (6) archeological; and (7) historic. These resources and/or features are discussed in the following sections.

4.3.1 Land Resources and Features

Notable land features include prominent, unusual, or fragile land uses or landscape features within the AOI.

Agricultural Lands, Farming and Ranching, Prime and Unique Farmlands

Agricultural lands and agricultural production are considered notable because they are the land uses that link the present physical landscape with important historical traditions of nineteenth century settlement. In many areas agriculture is an economic activity that is under threat from single-family housing and other development.

Agricultural lands within the AOI are composed primarily of native rangelands which comprise about 15 percent of total AOI acreage. About 15 percent of the AOI is classified as prime farmland by the NRCS. Only about one-half percent of AOI acreage is classified as cropland. These rangelands are typical of the Texas Hill Country landscape, with rolling hills and varying topography and vegetative communities. The soils that make up the vast area of native rangelands are shallow limestone, highly calcareous soils with interspersions of karst limestone. The variety of types of natural vegetation in the AOI is reflected in the distribution of livestock in the region. Cattle, for instance, are grazed on the typical mesquite-shrub, short-grass areas, characterized by deeper soils. Such areas are the best grazing lands of the region. The next best grazing areas support sheep grazing, while the poorest support goats. Limited crop farming is carried on in the deeper soils along the broader valleys in the northeast quarter of the Edwards Plateau. Although some cotton is grown, much of the agriculture is devoted to grain sorghum production as an adjunct to the predominant livestock enterprises.

Areas of deeper soils within the larger stream basins have supported more intensive farming since European settlement of the area. Small grain and feed crops were the primary crops grown, but these have mostly given way to improved pastures of Bermuda grass and other forage grasses over the years. Livestock grazing and hay production are the primary use of the forage crops being grown today. There has been some limited participation within the AOI in the recent trend of developing vineyards and wineries on Hill Country agricultural lands.

Unusual Landscape and Geological Features, Scenic Areas: Karst Geology and Devil's Backbone

The AOI lies along the southern margin of the Edwards Plateau with terrain influenced by surface expressions of the Edwards Group and Glen Rose Formation limestone, and the landscapes of the Balcones Fault Zone. These formations contain important groundwater resources: the Edwards and Trinity aquifers. The landscape in this area is related to the function of these aquifers and is characterized by karst features which collect surface water runoff and recharge it to the subsurface as groundwater, and transport the groundwater via porous rock and underground conduit systems. Surface landforms commonly seen in this terrain are recharge features such as sinkholes, streambed sections, enhanced permeability features such as active and relict caves, and discharge features such as perennial and ephemeral springs and seeps.

A highlight of one of Texas' most scenic drives, the "Devil's Backbone" is a winding, razor-backed ridge overlooking Hill Country vistas along the northern edge of the AOI. RM 32 is a little traveled scenic road that extends from RM 12, south of Wimberley, west approximately 24 miles to near Blanco. The portion of the road that runs along the

Devil's Backbone covers about 1.5 miles from roughly Spanish Eyes Road to Shellyhom Road. The ridge runs east to west, rising to an elevation of 1,274 feet above mean sea level at a roadside park on RM 32. It lies at the far northeastern end of the AOI, and is an example of the scenic landscapes found in many areas along the Balcones Escarpment.

Major Military Installations – Camp Bullis

Camp Bullis is a 28,000-acre military training site located north of Loop 1604 and approximately 3.5 miles to the west of US 281 in Bexar County. The facility's mission is to provide combat medical training and ground combat training for the Army, Navy, and Air Force. Development is approaching Camp Bullis and threatens its mission. Lighting around the base negatively affects nighttime training, and clearing the land around the base results in increased use of on-base habitat by the GCWA, which takes training areas out of commission. The City of San Antonio and Bexar County have taken steps to protect the military installation guided by the *Camp Bullis Joint Land Use Study* (City of San Antonio et al. 2009c). Recent or in-progress initiatives include City of San Antonio lighting and endangered species ordinances, and a regional habitat conservation plan. Camp Bullis is described as a prominent and regionally important feature and, although not subject to direct development, the base is included within the delineation of the AOI because of the sensitivity of its military operations in regard to external influences of development in the surrounding area.

Parks and Trails

Two state park facilities are located within the AOI. Guadalupe River State Park is a 1,939 acre park located in Comal and Kendall Counties. Four miles of the Guadalupe River flow through the park. Outdoor activities include canoeing, fishing, swimming, tubing, picnicking, hiking, camping, and equestrian trails. Honey Creek State Natural Area covers 2,294 acres in Comal County, adjacent to the Guadalupe River State Park and is accessible by guided tour only. Both the Upper Guadalupe River and Honey Creek have been designated by the Texas Parks and Wildlife Department (TPWD) as Ecologically Significant Stream Segments.

The US Army Corps of Engineers (or the Corps) maintains eight parks around Canyon Lake that provide sites for tent camping, RV camping, and screened shelters. These parks are Potter's Creek, Canyon, Canyon Beach, Crane's Mill, North, Comal, Guadalupe, and Overlook Park. The Corps also maintains five trails for hikers, birders, cyclists, or horseback riders.

4.3.2 Socioeconomic and Community Resources

Community Cohesion and Quality of Life

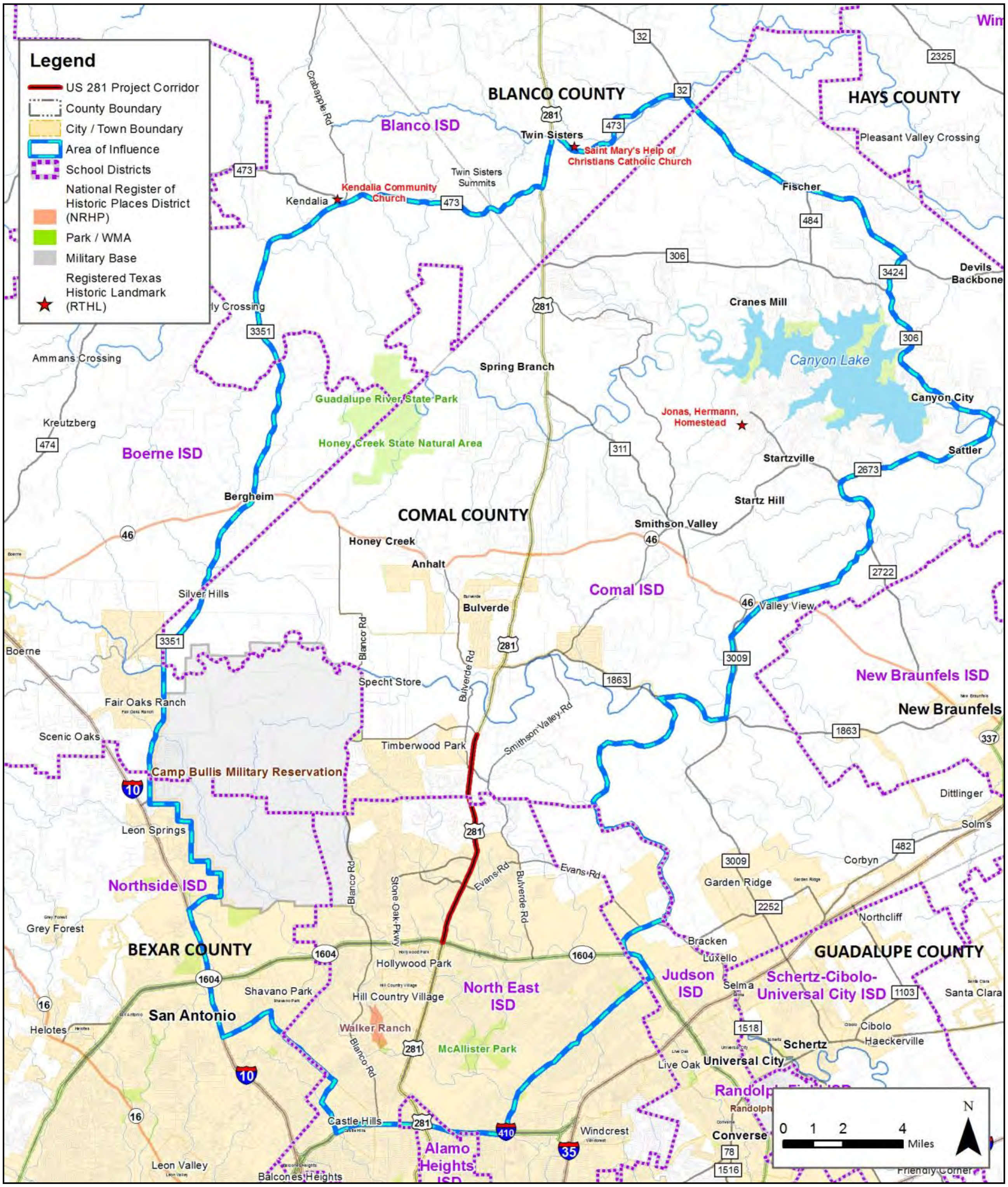
The towns, neighborhoods, and other population centers within the AOI that are considered notable are those whose quality of life, stability, cohesion, or unique identity could be indirectly affected by encroachment-alteration, or induced development effects of the proposed action. These characteristic elements may be economic, demographic, social, or physical. For example, physical land use changes associated with new development could affect the percent of open space in and around a town; alter its area, form and perception of town center or "edge;" or affect circulation and traffic patterns, architectural diversity, residential density, noise levels, lighting, or visual character of a community.

Social, economic, and demographic effects could be manifested as changes in occupational mix or income distribution, balance between long-time residents and newcomers, infrastructural burdens, or increased revenues to local businesses from new residents and visitors.

There are some areas in the North San Antonio portion of the AOI that have predominantly minority populations. **Appendix G** provides tables and a map that shows this information based on Census Tracts used in the 2010 Census. Census Tracts within the AOI having 50 percent or greater minority populations are all located south of Loop 1604, in a portion of the AOI that is more or less fully developed, and which is outside of the project corridor. Note also that the SA-BC MPO's Metropolitan Transportation Plan employs a threshold of 63.7 percent minority to identify Environmental Justice populations, since the MPO study area is a majority-minority region. These elements of the population are not considered to be notable features for this analysis because they would not reasonably be expected to be substantially impacted by indirect effects of the US 281 Build Alternatives. There is one Census Tract within the AOI that has a median household income below the poverty level, based on the 2008-2012 American Community Survey (see **Appendix G**). Census Tract 1818.20 is located south of Loop 1604 in Bexar County.

Other kinds of indirect effects relate to perceived changes in the historical and aesthetic character of an area, affecting the shared identity and sense of place that underlies the cohesion of the community. These growth-related changes are not uncommon in the rural areas surrounding rapidly growing cities, and are familiar to long-time residents of Hill Country towns like Kerrville, Cedar Park, or Boerne. Communities, including the city of San Antonio and other populated places in the AOI, are described as notable features below and identified on **Figure 4-4,** which also shows the boundaries of the Independent School Districts (ISD) located within the AOI. The ISDs which serve areas within the AOI include: Alamo Heights, Blanco, Boerne, Comal, Judson, Northside, and North East. As **Figure 4-4** shows, Comal ISD serves the largest portion of the AOI.

Figure 4-4: Landscape features, communities, designated historic sites and independent school districts



Source: US 281 EIS Team, 2010

City of San Antonio

The US 281 AOI includes part of the north sector of the city of San Antonio. While much of the AOI lies beyond San Antonio's corporate boundary, it is the city and the growth engine of its economy that establishes the context for the travel demand and associated potential indirect development effects of the proposed action.

San Antonio is characteristic of other rapidly growing southwest urban centers in which there are sparsely populated areas outside of the urban core. According to the US Census Bureau 2012 estimates, the city had a population of 1,382,951, ranking it the seventh-most populated city in the country. Due to the relatively low residential density outside the city limits, the San Antonio metropolitan area ranked just 25th in the US with a population of 2,234,003 in 2012.

Other Communities in the AOI

Traveling north out of San Antonio, across Cibolo Creek and the Bexar County line, the landscape of the AOI transitions from residential and suburban commercial development along the more southerly US 281 project corridor to the more traditional, rural Central Texas Hill Country influenced by heavy post-Civil War German immigration. Many of the areas more distant from San Antonio and New Braunfels are still characterized by small communities and family-owned farms. Kendalia and Bergheim in Kendall County, Bulverde, Honey Creek, Spring Branch, Smithson Valley, and Fischer Store in Comal County, and Twin Sisters in Blanco County are identified as populated places on USGS maps of the AOI. They are examples, or in some cases remnants, of small communities within the AOI that are typical of the settlements founded by early Hill Country farmers and ranchers. Other small communities of the AOI include: Anhalt, Canyon City, Cranes Mill, Sattler, and Startzville.

Due to their proximity to the proposed project area, potential effects to specific communities, including Bulverde, Hollywood Park, and Hill Country Village (as described in **Section 3.4.2 Neighborhoods and Community Cohesion**) are discussed with regard to changes in community cohesion and traffic patterns. Additionally, the potential effects of tolling on traffic patterns and household incomes in these communities are also considered in **Section 3.4.6 Environmental Justice**.

4.3.3 Air Quality

Air quality and climate are generally considered regional environmental issues. Air quality is identified as a notable feature for the purposes of the indirect impacts assessment because of the close relationship between air quality and regional transportation planning.

4.3.4 Water Resources and Features

Surface Water

The surface water streams that flow across the AOI originate in the Balcones Canyonlands Subregion of the Edwards Plateau Ecoregion and continue to flow in a generally southeasterly direction to traverse the northern margin of the Texas Blackland Prairies Ecoregion (Griffith et al. 2007) in the southernmost portion of the AOI. The hilly topography that characterizes the eroded southern border of the Edwards Plateau contains the headwaters of numerous sub-watersheds within the AOI. Most of these headwaters contribute to the larger drainage areas of the Guadalupe River and Cibolo Creek in the central part of the AOI, Salado Creek and the upper San Antonio River headwaters draining the southern portion of the AOI, Dry Comal Creek draining a portion of the southeastern AOI, and the Blanco River draining the northernmost corner of the AOI. Hillside and in-channel springs and seeps emanating from the Edwards Formation and Glen Rose Limestone Formation provide year-round base flow for many of the tributary and mainstem streams. Periodic drought in the region can lead to greatly reduced base flows in streams of the area. The same base flows feed the underground aquifers, particularly the Edwards Aquifer. Base flow is lost from stream channels as the streams cross the karst Edwards Aquifer Recharge Zone in the southern portion of the AOI, and areas of the Recharge Zone that lie to the east of the AOI.

The streams and rivers in the AOI represent a range of water quality and aquatic ecosystem conditions, from high quality waters and aquatic ecosystems of statewide and national significance to notably degraded water quality and aquatic ecosystems. Surface water notable features include high quality streams and aquatic ecosystems as well as streams identified as having important water quality concerns.

Ecologically Significant River and Stream Segments Identified by Texas Parks & Wildlife Department (TPWD)

The following rivers and streams within the US 281 Project AOI or with drainage areas within the AOI are among the ecologically significant rivers and streams identified by TPWD for Region L.

- Upper Guadalupe River is designated for its important hydrologic function relating to Edwards Aquifer discharge; the riparian conservation area within the Guadalupe River State Park; high water quality and exceptional aquatic life use; high aesthetic value - rated the number two scenic river in the state of Texas; and for threatened or endangered species/unique communities due to presence of the Plateau shiner (*Cyprinella lepida*), Guadalupe darter (*Percina sciera apristis*), and headwater catfish (*Ictalurus lupus*).
- Honey Creek is designated for its biological function in terms of overall habitat value considering the degree of biodiversity and uniqueness observed in the terrestrial and aquatic habitats; hydrologic function relating to groundwater discharge and recharge; the riparian conservation area within the Honey Creek State Natural Area; threatened or endangered species/unique communities due to presence of Guadalupe bass (*Micropterus treculi*), Cagle's map turtle (*Graptemys caglei*), Comal blind salamander (*Eurycea tridentifera*), green kingfisher (*Chloroceryle americana*), and the four-lined skink (*Eumeces tetragrammus*). The waters in Honey Creek emerge from Honey Creek Cave, the longest mapped cave in Texas at 20.2 miles in length.
- Blanco River (the Little Blanco River and Carpers Creek tributary drainages are within the AOI) is designated for its important hydrologic function relating to discharge from the Edwards and Trinity aquifers; the riparian conservation area within the Blanco River State Park; high water quality and exceptional aquatic life use; exceptional aesthetic value; and for threatened or endangered species/unique communities due to presence of the Blanco blind salamander (*Eurycea robusta*) (St. T), the Blanco River Springs salamander (*Eurycea pterophila*) (SOC), and the Guadalupe bass (*Micropterus treculi*).

- Carpers Creek is designated for its high water quality, exceptional aquatic life use, and high aesthetic value. It has been recognized as an ecoregion reference stream for its diverse macro-invertebrate community.

Upper Guadalupe River

In addition to its listing by the TPWD, the upper Guadalupe River is notable as a water resource of national and regional importance. The 81-mile segment of the river from the Canyon Lake headwaters to the river's headwaters upstream of Kerrville is included on the Nationwide Rivers Inventory (NRI) maintained by the National Park Service (NPS). The upper Guadalupe River is also included in the Nature Conservancy's national aquatic portfolio of critical watersheds for protecting freshwater biodiversity.

The NPS established and maintains the NRI as a national listing of free-flowing river segments that are potentially eligible for protection under the Wild and Scenic Rivers Act of 1968 (Public Law 90-542). Section 5d of the Act calls for an inventory of potential national wild, scenic, and recreational river segments for use in future water planning and development. Pursuant to a 1979 Presidential Directive and related CEQ guidance, all federal agencies must consider the effect of their actions on NRI river segments, may need to consult with the NPS through their normal environmental analysis processes, including the CEQ's NEPA procedures, and should seek to avoid or mitigate adverse effects on NRI segments. In order to be listed on the NRI a river segment must be free-flowing and must possess one or more "outstandingly remarkable" natural or cultural values that go beyond local or regional significance. Outstandingly remarkable river-related values are defined in NPS guidance as unique, rare, or exemplary features that are significant at a comparative regional or national scale. In its 1982 listing of the upper Guadalupe River for outstanding scenic, recreation, geologic and other values, the NPS provides the following description of this segment (NPS 2010):

> ***"Rated as #1 recreational river in the state, and #2 scenic river. A segment of the river was previously recommended as a Scenic Waterway. It is heavily used by canoeists, kayakers and tubers. At Edge Falls (on Curry Creek tributary), existence of extremely rare Styrax plantnifolia (silverbell tree) has been noted. Many Spring fed streams supply the river with a constant flow of good quality water. There are two major waterfalls and numerous rapids. Limestone bluffs line the river. Interesting limestone formations occur, such as travertine and flowstone/dripstone."***

The Nature Conservancy has compiled an aquatic portfolio of 327 critical small watershed areas across the continental United States that represents national priorities for freshwater biodiversity protection and conservation, for globally-ranked species at risk (Natural Heritage Ranks of G1, G2, and G3). The watershed selection process was based on a rarity-weighted richness index and additional factors that ensure inclusion of biodiversity hotspots and adequate coverage of all 465 G1–G3 fish and mussel species. The Conservancy reported that protecting and restoring these 327 watersheds, which represent 15 percent of the total number of small watersheds in the 48 contiguous states, would conserve populations of all at-risk freshwater fish and mussel species in the United States (Master et al. 1998). Three stream segments that are within the US 281 Project AOI and/or have drainage area within the AOI are contained in this aquatic portfolio: the upper San Antonio River with four at-risk fish and mussel species and the upper Guadalupe River and middle Guadalupe River are listed with three identified at-risk fish and mussel species. The Guadalupe River is further highlighted as one of eight "Rivers of Life" in the nation where individuals, organizations and agencies are working together to conserve freshwater biodiversity (Master et al. 1998). The river is noted as providing habitat for four endemic fish species: the Guadalupe bass (*Micropterus treculi*), the fountain darter (*Etheostoma fonticola*), the greenthroat darter (*Etheostoma lepidum*), and the gray redhorse (*Moxostoma congestum*). The predominance of relatively undeveloped rangeland in the watershed is noted as are the threats associated with human population growth with increasing water demand and residential and recreational development. The interest of fishing and other water recreation users (and associated businesses) in conserving the river ecosystem is noted as a factor in mobilizing conservation efforts.

Other Priority Waterbodies for Aquatic Biodiversity Conservation

In its *Biodiversity and Conservation Assessment of the Edwards Plateau Ecoregion*, the Nature Conservancy identified aquatic conservation targets for the Guadalupe/San Antonio River Ecological Drainage Unit that include five amphibian species, four fish species, two insect species, three mollusk (mussel) species, one reptile and one aquatic plant as biological components (The Nature Conservancy 2004). Ecoregion conservation targets include species that have a Natural Heritage Global Rank of G1 (critically imperiled) to G3 (vulnerable). Conservation targets were set for representative aquatic systems (e.g., creeks/headwaters, small rivers, medium rivers, and large rivers) in addition to targets for aquatic life species. One of the goals of this landscape scale assessment is to identify the best remaining examples of biodiversity that are representative of the ecoregion, and to document "occurrences" of conservation targets that are viable, meaning that they have a reasonable chance of survival over a 100-year timeframe. The assessment also identified threats associated with the conservation targets.

Waterbodies identified in the aquatic portfolio as aquatic systems associated with target species include the following streams that are within the US 281 Project AOI and/or have drainage area within the AOI: the Blanco River (for the Blanco River Springs salamander, Cagle's map turtle, Edwards Plateau spring salamander, and Guadalupe bass); the Guadalupe River (for the Cagle's map turtle, Edwards Plateau spring salamander, golden orb, Texas fatmucket, Texas pimpleback, Guadalupe bass, and headwater catfish); Honey Creek (for the Edwards Plateau spring salamander and Guadalupe bass); the San Antonio River headwaters/Salado Creek as aquatic systems, and Leon Creek (for the Edwards Plateau spring salamander and Texas salamander). It is notable that of the nine at-risk species targeted within the above-named aquatic systems, viable occurrences were documented for only two of these species in one aquatic system: the Blanco River Springs salamander and Cagle's map turtle in the Blanco River system (one occurrence of each species was documented). For the other seven species and the remaining aquatic systems, no viable occurrences of at-risk species were documented in the assessment.

Canyon Lake

Canyon dam on the Guadalupe River was completed in 1964 to form Canyon Lake reservoir in the northeast portion of the AOI. At Conservation Pool Level, Canyon Lake reservoir has a capacity of 382,000 acre-feet and a surface area of 8,240 acres. Canyon Lake offers many kinds of recreation including camping, picnicking, trails, boating, hunting, fishing and swimming, and also serves an important flood control function. The reservoir is a major water supply source for areas within the AOI and beyond, and is an important element of the surface water strategies for several communities and water providers, as well as for downriver agriculture, as outlined in the *2011 South Central Texas Regional Water Plan* (SCTRWPG 2010).

Water Quality Impaired Streams

The Clean Water Act 303(d) List is prepared every two years by the TCEQ to identify impaired surface waters that are considered to be water-quality limited, meaning that effluent limitations are not stringent enough to achieve water quality standards for certain listed pollutants, and therefore the listed pollutants should be addressed by maximum daily load (TMDL) (TCEQ 2012). TMDL studies are then planned, conducted, and implemented to address the 303(d)-listed water quality impairments, and once a TMDL is approved a waterbody may be delisted for the pollutant addressed by the TMDL. The approved 2012 Texas 303(d) List includes portions of five surface water segments that are within or have drainage areas within the AOI. These are: Canyon Lake (Segment 1805), Guadalupe River above Canyon Lake (Segment 1806), Upper Cibolo Creek (Segment 1908), Dry Comal Creek (Segment 1811A), and Upper San Antonio River (Segment 1911). Lower Leon Creek (Segment 1906) is also on the 2012 303(d) List for depressed dissolved oxygen and PCBs in edible fish tissue. However, Leon Creek is not considered to be a notable feature because only a very minor amount of the AOI, 591 acres at the western corner of Camp Bullis, drains to the uppermost portion of the creek.

- Canyon Lake is listed for having mercury in edible tissue; the sources of contamination are listed by the TCEQ as atmospheric deposition and unknown sources.
- Guadalupe River above Canyon Lake was first listed in 2002 and is on the 2012 303(d) List for bacterial contamination from 25 miles upstream of the lower end of the river to its confluence with Big Joshua Creek. The TCEQ indicates that the pollution source is unknown.
- Upper Cibolo Creek from the Missouri-Pacific Railroad Bridge west of Bracken in Comal County to a point 0.9 mile upstream of the confluence of Champee Springs in Kendall County is listed on the 2012 303(d) List for bacterial contamination (first listed in 2006) and for chloride (first listed in 2012). The TCEQ indicates that the pollution source is unknown.
- Dry Comal Creek was added to the 303(d) List in 2010 due to bacterial contamination affecting the lower 25 miles of the stream. The upper approximately 2.5 miles of this impaired section are within the AOI. TCEQ lists the pollution source as unknown.
- Upper San Antonio River is listed for having an impaired fish community. A previous listing for bacterial contamination in the upper San Antonio River was removed from the 2008 303(d) List because a TMDL has been approved by the TCEQ to address this impairment. The sources of impairment are indicated by the TCEQ to be unknown point and nonpoint sources.

Groundwater

Aquifers and Associated Recharge Features and Springs

The Edwards was the first aquifer in the nation to be designated as a Sole Source Aquifer (in 1975) under the provision of Section 1424(e) of the Safe Drinking Water Act. To be eligible for this designation an aquifer must supply greater than 50 percent of the drinking water for an area that has no reasonably available alternative sources of drinking water. Notable recharge features of the Edwards Aquifer within the AOI include the streambeds of named creeks and streams that pass over the recharge zone, recharge areas in surface water impoundments that create high hydraulic gradients, and discrete recharge through a variety of caves, pits, and sinkholes.

There are many thousands of recharge features associated with the Edwards and Trinity aquifers. Both empirical data and ancillary information concerning the most significant recharge features of the Edwards and Trinity aquifers are gathered from LBG-Guyton Associates (2005), Veni (1988), Zara (2008), and the database of the Texas Speleological Survey (2012).

Notable recharge features in the Trinity Aquifer include recharge from Canyon Lake and other water impoundments, and a number of documented caves, pits and sinkholes.

Portions of four of the nine basins characterized by LBG-Guyton Associates (2005) that contribute recharge to the Edwards Aquifer are within the AOI for the US 281 Project. As grouped by the LBG-Guyton Associates Study, these are: (1) the watersheds between the Medina River basin and Cibolo Creek basin; (2) the Cibolo-Dry Comal basin; (3) the Guadalupe River basin; and (4) the Blanco River basin. For these four basins, the apportionment of total recharge between the channel loss and the land surface mechanisms is shown on **Table 4-4**. These data reflect the current understanding of aquifer recharge dynamics, the knowledge of which is evolving as a result on recent and ongoing studies. While it previously was widely assumed that the majority of recharge occurred via channel loss, the recent analyses conducted for the EAA concluded that on average, over the entire nine-basin area, approximately 50 percent of the recharge occurs on land surfaces and 50 percent occurs as channel loss (LBG-Guyton Associates 2005; EAA 2009b). Previous EAA-supported efforts to refine an Edwards Aquifer model had relied on an assumption that 85 percent of aquifer recharge occurred in stream channels, based on a water balance approach using records from USGS stream gages measuring streamflow upstream and downstream of the Recharge Zone (Todd Engineers 2004).

Table 4-4: Aquifer Recharge by Watershed Groups

Watershed Groups Traversing the AOI	Recharge contribution		Contribution to Total Edwards Aquifer Recharge[1]
	Channel Loss	Land Surface Mechanisms	
Watersheds between Medina River basin and Cibolo Creek basin	47%	53%	14.5%
Cibolo-Dry Comal	33%	67%	11.8%
Guadalupe River	36%	64%	3.2%
Blanco River	24%	76%	12.5%
Total Contribution of Watersheds			42.0%

Source: LBG-Guyton Associates 2005.
[1] Proportion of total cumulative recharge, 1950 to 2000.

The LBG-Guyton study also found (as shown in **Table 4-4**) that the four watershed groups contributed an estimated 42 percent by volume of the total cumulative Edwards Aquifer recharge over the period from 1950 to 2000; with the watersheds between the Medina River and Cibolo Creek contributing 14.5 percent, the Cibolo-Dry Comal basin contributing 11.8 percent, the Guadalupe River contributing 3.2 percent, and the Blanco River contributing 12.5 percent. The recharge contributions given in **Table 4-4** reflect watersheds as they were grouped for the LBG-Guyton study. These watersheds traverse the AOI, but they also include drainage areas and portions of the Edwards Aquifer Recharge Zone that are to the northwest and west of the AOI. An undetermined portion of the recharge contributions presented in **Table 4-4** would be associated with lands and streams within the AOI.

In Bexar County, more than 40 caves or other discrete recharge features have been identified by various investigations (including Zara and Veni 2008). Of these, the following named features are located within the AOI. Backhole, Banzai Mud Dauber Cave, Bet-Ya-Can't-Find-It Cave, Bear Cave, Blanco Road Cave, Boneyard Pit, Bullis Hole, Camp Bullis Bad Air Cave, Camp Bullis Bat Cave, Camp Bullis Cave No. 1, Camp Bullis Cave No. 3, Cave of the Creek, Cave of the Woods, Cibohole, Corkscrew Cave, Dead Deer Cave, Eagles Nest Cave, Elm Springs Cave, 50 Bucket Cave, Fair Hole (Bexar, Comal and Kendall Counties), Genesis Cave, Georg's Hole, Grosser's Sink, Hill's and Dale's Pit, Hold Me Back Cave, Hornet's Last Laugh Cave, Hunting Headquarters Cave, Jabba's Giant Sink, MARS Shaft, MARS Pit, Poison Ivy Pit, 17-foot Pit, Poor Boy Baculum Cave, Root Canal Cave , SARA Site 4 Cave, Shavano Park Cave, Stealth Cave, Summerglen Cave, Twin Sinks Cave, and Wedge Cave.

Other important Edwards Aquifer recharge features include Johnson's Swallet, Tarbutton Showerbath Cave, and Blanco River Swallet (all in Hays County); and Boehme's Cave in Medina County.

Springs

Springs of the Edwards and Trinity aquifers have been documented by Brune (1981), the database of the Texas Speleological Survey and other sources. The San Antonio Segment of the Edwards Aquifer supports the two largest springs in Texas, San Marcos Springs in Hays County, and Comal Springs in Comal County, which are located beyond the AOI but could be affected by development over other areas of the recharge zone. Other important springs of the Edwards Aquifer near the AOI include: Hueco Springs in Comal County, and San Antonio Springs and San Pedro Springs in Bexar County. Seven federally endangered and one threatened species are dependent on the San Marcos and Comal Springs ecosystems. These include two salamanders, the Texas blind salamander *(Eurycea rathbuni)* and San Marcos salamander *(Eurycea nana)*; two fishes, the fountain darter *(Etheostoma fonticola)* and San Marcos gambusia *(Gambusia georgei)*; two aquatic insects, the Comal Springs riffle beetle *(Heterelmis comalensis)* and Comal Springs dryopid beetle *(Stygoparnus comalensis)*; one crustacean, Peck's Cave amphipod *(Stygobromus pecki)*; and one plant, Texas wild-rice *(Zizania texana)*. These species are included among the ecological notable features discussed in **Section 4.3.5 Ecological Resources and Features**.

Important springs of the Trinity Aquifer within the AOI include Magic Springs, Rebecca Springs, Bishop Springs, Fischer Springs, and Honey Creek Cave. Some of these springs discharge into Canyon Lake.

4.3.5 Ecological Resources and Features

Threatened and Endangered Species

The notable ecological features within the US 281 AOI include a number of populations and habitats of threatened and endangered species. This area has unique habitat types such as terrestrial karst and sub-surface aquifer environments as well as oak-juniper woodlands and canyonlands. In response to these threats, the TPWD, USFWS and other organizations have listed many of these species as threatened or endangered in order to protect the species and their habitats.

To provide context the following overview presents information about the listing, mapping and conservation of the threatened and endangered species and their habitats in the proposed US 281 project area. Based upon a review of TPWD and the USFWS county lists, TPWD Natural Diversity Database (TxNDD) data and other sources, the principal species identified as notable features are the federal- and state-listed species of birds, terrestrial karst species, surface water aquatic species (mussels, turtles and fish) and aquifer species (invertebrates, salamanders and fish) found to occur or with potential habitat within the AOI. Specifically, the TPWD TxNDD documents 49 occurrences of state-or federally-listed species in the AOI as indicated in **Table 4-5.**

Table 4-5: State - and Federally-Listed Species Occurrences in AOI

Species	Occurrences	Listed by Federal or State
Golden-cheeked Warbler (*Setophaga chrysoparia*)	26 (11,408 acres occupied)	F, S
Cascade Caverns Salamander (*Eurycea latitans* complex)	7	S
Edwards Plateau Spring Salamanders (*Eurycea* sp. 7)	3	S
Comal Blind Salamander (*Eurycea tridentifera*)	9	S
Cagle's Map Turtle (*Graptemys caglei*)	1	S
A Ground Beetle (*Rhadine exilis*)	2	F
A Ground Beetle (*Rhadine infernalis*)	1	F

Source: TPWD Natural Diversity Database (TxNDD), 2011.

The occurrences and potential habitat areas of these species are generally described in the profiles below. Quantifications of TxNDD data should be relied on only for trend or general potential occurrence purposes only. This database documents only occurrence data provided by cooperative researchers and varies greatly depending upon the precision of the data provided. For example, the dominant data sources in the AOI are researchers at federal and state facilities such as Camp Bullis, Guadalupe River State Park and Honey Creek State Natural Area. Given the lack of precision for locality information in some cases, some sensitive populations or habitats generally known from a county are mapped very broadly and/or not shown at all. In other cases, species can be listed as occurring in counties they migrate through or have only historical, short term or sporadic presence in. Such species, like the Peregrine falcon (migrant), white-faced Ibis (incidental), wood stork (incidental) and zone-tailed hawk (northeast of principle range) will not be carried forward for indirect or cumulative impact analysis. Finally, given the ecotonal transitions between Edwards Plateau, South Texas Plains and Blackland Prairie in Bexar County, the county lists include species not expected to occur in the AOI such as Texas indigo snake and Texas tortoise (South Texas brush species).

Terrestrial Karst Species

Bexar County is one of the most heavily studied counties with respect to karst fauna. There are nine federally listed karst invertebrate species that occur in Bexar County (USFWS 2010a), and six of those occur within the AOI and are listed below:

Madla Cave Meshweaver (Cicurina madla)

The Madla Cave meshweaver (*Araneae: Dictynidae*) is a pale, eyeless spider. This species inhabits caves and mesocavernous voids, including those with sparse organic input. *C. madla* has been confirmed in 22 Bexar County caves in Government Canyon, Helotes, University of Texas San Antonio (UTSA) and Stone Oak karst faunal regions (KFRs), and may occur in two additional caves in the Helotes and Stone Oak KFRs (USFWS 2011b).

Robber Baron Cave Meshweaver (Cicurina baronia)

The Robber Baron Cave meshweaver (*Araneae: Dictynidae*) is a small, eyeless spider known only from caves formed in the Austin Chalk and located in the Alamo Heights KFR.

Cokendolpher Cave Harvestman (Texella cokendolpheri):

The Cokendolpher Cave harvestman (*Opilionida: Phalangodidae*) is a small, pale orange, essentially eyeless, harvestman. Juvenile specimens are known to be white to yellowish-white in color. *Texella cokendolpheri* was first collected in 1982 and described by Ubick and Briggs (1992). It is known from one locality (Robber Baron Cave) in the Alamo Heights KFR.

Ground Beetle (No Common Name) Rhadine exilis:

Rhadine exilis (*Coleoptera: Carabidae*) is a slender, essentially eyeless, ground beetle that reaches a length of about 7.4 mm. It inhabits caves that have natural entrances; it is not known to have been encountered in accidently discovered voids during construction activities. It was first collected in 1959 and described as *Agonum exile* but later assigned to the genus *Rhadine* (Barr 1974). The species is currently confirmed in 51 caves in the Government Canyon, Helotes, UTSA, and Stone Oak KFRs and may occur in two additional caves in the UTSA KFR in Bexar County (USFWS 2011b).

Ground Beetle (No Common Name) Rhadine infernalis:

Rhadine infernalis (*Coleoptera: Carabidae*) is a small, slender-bodied, essentially eyeless ground beetle. It was first collected in 1959 and initially described as *Agonum infernale*, but later assigned to the genus *Rhadine*. USFWS (2011b) documents the species as occurring in 39 caves in the Culebra Anticline, Helotes, UTSA, and Stone Oak KFRs located in Bexar County; recent surveys have encountered this species in two additional caves within the Culebra Anticline KFR. Recently collected specimens were taxonomically verified by James Reddell (2014).

Madla Cave Meshweaver

Photo: Dr. Jean Krejca

Cokendolpher Cave Harvestman

Photo: Dr. Jean Krejca

Ground Beetle (*Rhadine exilis)*

Photo: Dr. Jean Krejca

Ground Beetle (Rhadine infernalis)

Photo: Dr. Jean Krejca

Helotes Mold Beetle (Batrisodes (Excavodes) venyivi):

The Helotes mold beetle (*Coleoptera: Staphylinidae*) is a small, troglobitic, reddish-brown beetle that resembles an ant. The species is currently known in 8 caves in the UTSA, Helotes and Government Canyon KFRs.

Helotes Mold Beetle

Photo: Dr. Jean Krejca

Aquifer and Spring Dependent Species

The following seven federally listed aquifer and spring-dependent species are not known to occur in the AOI; however, they are listed as notable species due to their dependence on high quality and specialized habitat which is ecologically connected to the Edwards Aquifer.

Texas Wild Rice (Zizania texana):

Texas Wild Rice grows only in the spring fed upper two miles of the San Marcos River. This plant prefers clear, cool, swift waters with soil substrate and grown in water that is less than one meter deep (TPWD 2010d).

Texas Wild Rice

Photo: Edwards Aquifer Website

Peck's Cave Amphipod (Stygobromus pecki):

Peck's Cave amphipod is a federally listed amphipod originally described from the type locality at Comal Springs, where they are still fairly abundant (Gibson et al. 2008). This amphipod can be white or bright orange, probably depending on the availability of food sources at the collection locality. *S. pecki* have been collected from organic and inorganic debris near springs and seeps at Comal Springs, Landa Lake, Panther Canyon Well, and Hueco Springs (Gibson et al. 2008; Krejca 2005).

Fountain Darter (Etheostoma fonticola):

The fountain darter is a small, reddish brown predatory fish found in Hays and Comal counties. Usually less than 25mm standard length, it is the smallest of the darters and is known only from the San Marcos and Comal rivers, where it prefers vegetated stream floor habitats and is often associated with mats of filamentous algae. It requires a constant flow of clear, clean water with stable temperatures, vegetation for cover, and undisturbed stream floors. Live specimens are kept at the San Marcos National Fish Hatchery and Technology Center.

Fountain darter

Photo: Edwards Aquifer Website

Comal Springs Dryopid Beetle (Stygoparnus comalensis):

The Comal Springs dryopid beetle is the only known subterranean member of the beetle family Dryopidae. These long, slender dryopid beetles are about 1/8 inch long as adults, with a thin outer covering and reddish-brown color. Larvae are elongate, cylindrical and yellowish-brown. They have vestigial (non-functional) eyes, are weakly pigmented, translucent, and thin-skinned. The species has been found in two spring systems (Comal Springs and Fern Bank Springs) located in Comal and Hays counties, respectively. Dryopid beetles live primarily in flowing, uncontaminated waters. Biologists find adults and larvae of this aquifer species primarily in drift nets or cotton cloth traps at spring upwellings (Gibson et al. 2008).

Comal Springs dryopid beetle

Photo: Joe N. Fries

Comal Springs Riffle Beetle (Heterelmis comalensis):
The Comal Springs riffle beetle, is a small aquatic, surface-dwelling species in the family *Elmidae*. Adult Comal Springs riffle beetles are about three mm long, with females slightly larger than males. Larvae are up to 10 mm long, with an elongate tubular body. The specific name is for the type locality, Comal Springs. This species is known from two localities: San Marcos Springs in Hays County and Comal Springs in Comal County. It occurs in the gravel substrate and shallow riffles in spring runs. Biologists have found adults and larvae primarily in drift nets or cotton cloth traps at spring upwellings (Gibson et al. 2008).

Comal Springs riffle beetle

Photo: Joe N. Fries

Texas Blind Salamander (Eurycea rathbuni):
The Texas blind salamander is an aquatic salamander in the family *Plethodontidae.* It is a large (up to 13 cm long) cave and aquifer dwelling salamander distinguishable from other central Texas *Eurycea* by the lack of pigment that leaves it with a pearlescent color, extremely broad and flattened head shape, long spindly arms, deeply finned tail, and extremely reduced eyes visible as two small dark spots beneath the skin. This species feeds on insects and other small invertebrates that live in subterranean waters. The USFWS recognized populations of the Texas blind salamander occur in wells, caves and springs fed by the waters of the Edwards Aquifer in San Marcos, Hays County, Texas; however, a recently discovered population of eyeless *Eurycea* at four New Braunfels sites (Comal Springs, Hueco Springs, Mission Bowling Well, and Panther Canyon Well) is also likely to be this species. Genetic work on eyeless *Eurycea* from the New Braunfels sites reported in Chippindale (2009) and Gluesenkamp and Chippindale (2011) indicate the likely identity of these specimens is Texas blind salamander.

Texas Blind Salamander

Photo: Edwards Aquifer Website

San Marcos Salamander (Eurycea nana):
The San Marcos salamander is an aquatic salamander in the family *Plethodontidae*. It is about 2.5 inches long, slender, and displays a prominent gill fringe behind the head. It is light brown above with a row of pale flecks on each side of its midline and yellowish white underneath. This species is carnivorous and feeds on amphipods, midge fly larvae, and aquatic snails. The limited range of the San Marcos salamander includes the San Marcos Springs, Spring Lake, and a few hundred feet of the San Marcos River downstream of the springs (Eckhardt 2010a).

San Marcos Salamander

Photo: Joe N. Fries

Reptiles
Five reptiles state-listed as Threatened are known to have occurred in the AOI and two of these, the Texas horned lizard (*Phrynosoma cornutum*) and Cagle's map turtle (*Graptemys caglei*), are included within the set of notable features studied further in the indirect effects analysis sections. The three that are not carried further include the Texas indigo snake (*Drymarchon melanurus erebennus*) and the Texas tortoise (*Gopherus berlandieri*), both South Texas brush species, and the timber/canebrake rattlesnake (*Crotalus horridus*) – primarily an East Texas species.

Endangered Songbird Species

Golden-cheeked Warbler

The GCWA (*Setophaga chrysoparia*) is a small, neo-tropical songbird in the family Parulidae. Male GCWAs have a black back, throat, upper breast, and crown, white belly, black-streaked sides, white wing bars, and a black line through the eye with large yellow patches both above and below the eye. Female and immature GCWAs are duller, with olive upperparts with dark streaks and a yellowish or white chin (NatureServe 2010). The best known concentrations of GCWA within the AOI are found within Camp Bullis, Guadalupe River State Park and Honey Creek State Natural Area. Predictive models of high quality GCWA habitat also indicate potential occupation in an arc around the southern and eastern margin of the Edwards Plateau; and in the AOI particularly in northern Bexar, east-central Comal and eastern Kendall counties (Diamond 2007).

Golden-cheeked Warbler

Photo: [US Fish & Wildlife Service]

Black-capped Vireo

The BCVI (*Vireo atricapilla*) is one of the smallest vireos, measuring only 12 centimeters. The species is unique among vireos because it is sexually dichromatic and first-year males show delayed plumage maturation. The male BCVI has an olive green back, dark olive to blackish wings with two pale yellow wing bars, white underneath with yellow-tinged flanks, and a black head with white spectacles. Adult females have a gray head, as do the immature males (NatureServe 2010).

Black-capped Vireo

Photo: [Texas Parks & Wildlife Department]

4.3.6 Archeological Resources

Archeological notable features would include previously recorded sites within the AOI that are listed on the National Register of Historic Places (NRHP) or as State Archeological Landmarks (SAL). These designations indicate the degree of research potential a site may possess and are used as a general measure of importance when deciding the effects a project may have on valuable cultural resources. Sites listed on the NRHP or as a SAL are afforded greater legal protection than more common sites to preserve scientific data that have the potential to enhance our understanding of the prehistoric and historic archeological record of the area. Other notable features include areas identified as high archeological sensitivity zones in the archeological predictive model developed for this project. These areas were delineated based on available site location information within the archeological resource study area as well as general understanding of site distribution across the Central and South Texas Regions (Hester 2004; Collins 2004). These areas are typically located within floodplains and, therefore, have a higher potential for preserved archeological resources than other landforms.

Previously Recorded Sites

There are no previously recorded archeological sites listed on the NRHP within the AOI. Two sites are listed as SALs: Sites 41CM91 and 41CM92. Both sites are historic archeological sites located in Guadalupe River State Park and were recorded in 1975, a time when site recordation was less regulated. As a result, some information regarding the current condition of the sites is unknown. Site 41CM91 refers to the Richter House, a German-built house and associated outbuildings constructed in 1897. The Richter House is a single-component historic archeological site and encompasses as area measuring 90 square meters. Beyond its construction of stone, little information is available about the site. Site 41CM92, the Rust House, encompasses an area of approximately 40 square meters. The site consists of a wood frame house constructed out of juniper, cedar, and stone, as well as an associated outbuilding complex. Though further site information is unavailable, it can be assumed that these sites were listed as SALs due to their contribution to the archeological record as clear examples of early settlement in Central Texas in the late nineteenth and early twentieth centuries. Their location within the State Park reasonably assures their long term protection from future land development influences.

Zones of Archeological Sensitivity

A total of about 370 acres within the AOI lie within High Sensitivity Zones identified through the development of an archeological predictive model. Since land within the AOI has not been extensively surveyed and may not fall under federal or state jurisdiction, it is useful to address the likelihood of site occurrence within the AOI in order to assess the degree to which cultural resources could be indirectly affected. Though these theoretical sites may or may not be considered archeologically significant, the 370 acres identified as zones of high archeological sensitivity within the AOI are considered archeological notable features.

4.3.7 Historic Resources

Despite the rich history of the Hill Country, the AOI has relatively few federally- and state-recognized historic properties outside of the primary population centers. Some smaller communities contain individual historic properties, but the areas outside of larger cities have been under-documented. There is one Registered Texas Historic Landmark (RTHL) site and one NRHP historic district within the AOI, with two RTHL sites located on the boundaries of the AOI. These are indicated on **Table 4-6** and located on **Figure 4-4**.

Table 4-6: Historic Properties or Districts within or Adjacent to the AOI

Property/District	Designation	Quadrangle	Location
St. Mary's Help of Christians Catholic Church	RTHL	Spring Branch Quadrangle	northern AOI boundary
Kendalia Community Church	RTHL	Kendalia Quadrangle	northwestern AOI boundary
Hermann Jonas Homestead	RTHL	Smithson Valley Quadrangle	northeastern AOI
Walker Ranch	NRHP District	Castle Hills Quadrangle	southwestern AOI

Source: Texas Historical Commission Historic Sites Atlas Online, 2010

These sites are considered notable features for historic resources because they have been previously identified as significant. There are likely historic resources within the AOI which would meet NRHP eligibility criteria that have not been previously identified through NRHP or RTHL designations. The type, location, and relative uniqueness of individual resources cannot be determined without conducting a survey. The historically German communities, which are part of the historic context of the AOI, are considered in the Socioeconomic and Community Resources section (**Section 4.3.2 Socioeconomic and Community Resources**). As a dispersed resource over a large area, indirect effects to a specific resource would be unlikely to substantially affect the integrity of the entire rural historic landscape. However, the historic-built environment is a character-defining feature of these communities; therefore, rural historic districts and cultural landscapes are also considered as components of community resources.

4.4 STEP 4: IDENTIFY IMPACT-CAUSING ACTIVITIES OF PROPOSED ACTION AND ALTERNATIVES

Impact-causing activities are primarily the aspects of the proposed project design, construction, and operation that may result in impacts to the environment, particularly encroachment-alteration type impacts. Following the guidance from TxDOT (2010e) and NCHRP 466 (NCHRP 2002) along with experience with similar projects, the following activities are applicable to the proposed US 281 improvements.

Modification of Regime – Including Land Use, Vegetation and Hydrology

- Short-term changes in storm water runoff generation and routing will occur during the project construction phase
- Long-term changes in storm water runoff from impervious highway surfaces and changes in the way runoff is routed to receiving waters via the constructed drainage systems
- Pre-existing regimes will be preserved to some extent through the application of distributed storm water management techniques (also known as Low Impact Development techniques)
- Limited vegetation clearing will occur
- Major changes to existing land use and vegetation regimes within the immediate project construction corridor are not expected, because the proposed improvements are for expansion of an existing highway facility

Land Transformation and Construction

- Acquisition of ROW for the proposed project. This converts existing land uses, developed and undeveloped, to transportation use
- Removal of existing vegetation or other cover types, including asphalt or concrete, from the ROW
- Relocation of overhead and underground utilities
- Demolition and disposal of property improvements (houses, fences, buildings) or roadway features (existing pavement, culverts) within the ROW

Resource Extraction, Processing/Storage, Disposal

- Mobilization of equipment and resources to the area for the duration of the construction phase
- Stockpiling of materials (topsoil, steel rebar, road base fill, fuel and lubricants, concrete, signage)
- Solid waste disposal
- Excavation of off-site borrow material and truck hauling to the project site.
- Processing of concrete at an on-site or off-site batch or mixing plant

Land Alteration, Erosion Control, Fill

- Earthmoving activities
- Excavation and embankment construction

- Grading and temporary fill within streams; all jurisdictional waters subject to temporary impacts would be restored to pre-existing conditions
- Bridge construction
- Roadway placement
- Stabilization of exposed soils by seeding and revegetation
- Installation and maintenance of temporary and permanent erosion and sediment control measures

Chemical Treatments

- Fertilizer use in establishment of temporary and permanent vegetation within the ROW

Resource Renewal Activities

- Post-construction landscaping and revegetation practices would use native materials and species and avoid introduction of non-native species

Changes in Traffic Patterns, Access, Circulation, Travel Times

- Construction-phase traffic control or detours
- Long-term changes in accessibility and travel patterns associated with design modification of access roads and intersections; it is anticipated based on current design that there would be no access changes to individual properties or the existing road network
- Long-term changes in mobility due to increased roadway capacity and more efficient traffic movement through the area
- Accidents that may occur, with potential hazardous materials spills

4.5 STEP 5: IDENTIFY POTENTIALLY SUBSTANTIAL INDIRECT EFFECTS FOR ANALYSIS

The objective of this step is to analyze the impact-causing activities identified in Step 4 in the context of goals (Step 2) and notable features (Step 3) in order to explore potential cause and effect relationships and establish which effects are potentially substantial and merit subsequent detailed analysis. Potentially substantial effects are evaluated according to the types of indirect effects – encroachment-alteration, induced growth, and effects related to induced growth - to determine which potential effects will be carried forward for further analysis in Step 6 (**Section 4.6 Step 6: Analysis of Indirect Effects and Evaluate Results**). The rationale for how and why these determinations were made is summarized in **Section 4.5.4 Summary of Potentially Substantial Effects**.

For the No-Build Alternative, none of the impacts discussed below would occur. But the No-Build Alternative would not meet the Need and Purpose of the project.

4.5.1 Encroachment-Alteration Effects

Encroachment-alteration effects are focused on the relationships between the impact-causing activities of the proposed action and the resulting changes (encroachments or alterations) in the behavior and functioning of the affected environment, which may occur later in time or further away in distance from the direct effects of the action. Encroachment-alteration effects are usually categorized as either ecological or socioeconomic effects (NCHRP 2002, 55-56). **Table 4-7** addresses the potential encroachment-alteration effects for each resource and issue categories, discussing whether or not the effects are considered substantial enough to merit further analysis in Step 6, **Section 4.6.1 Encroachment-Alteration Effects**.

Table 4-7: Summary of Encroachment-Alteration Effects Analysis

Resource and/or Issue	Potential Encroachment-Alteration Effects	Further Analysis in Step 6
Land Use	The majority of the US 281 project corridor is largely developed, while remaining portions are currently undergoing development or redevelopment. Therefore, conversion of existing land uses to a transportation use as a result of the Build Alternatives would not represent a substantial encroachment-alternation effect to notable land uses, including agricultural lands, unusual landscape features, military installations or parks.	No
Farmlands	According to the NRCS, soils at the Build Alternatives project location may contain Important Farmland Soils. A total of 1.7 acres of soil map unit Tf-Tinn and Frio soils, 0 to 1 percent slopes, frequently flooded were determined to be within the project area. This Tf map unit has a rating of partially hydric, and precautions such as accepted erosion control methods during construction of the proposed project would be taken to avoid contaminating or destroying the potential wetland sites associated with this soil map unit. Additionally, the corridor has already been committed to urban uses. The FPPA excludes from the definition of "Farmland" areas that are already committed to urban areas. For these reasons, farmlands are not carried forward for analysis of encroachment-alteration impacts in Step 6.	No
Socioeconomic Resources	The Build Alternatives would not result in substantial encroachment-alteration effects related to travel patterns, access or business displacements. In addition, the Build Alternatives would not be expected to result in encroachment-alteration effects to EJ populations. **Effects of Changes in Travel Patterns or Access.** During the public meetings for the Draft EIS, a concern was raised that the project Build Alternatives might alter access to and between adjacent neighborhoods and commercial areas in a way that would adversely affect local residents. Sometimes, projects involving conversion to full control of access or changes in the design and alignment of ramps, frontage roads, intersections, and driveway locations can limit the convenience of access for nearby residents and other users of the facility. Moreover, access changes may lead to the re-routing of traditional travel patterns through neighborhood streets, affecting perceived noise and traffic in residential areas, and impairing visual and aesthetic values. Due to these concerns, the engineering design process focused on avoiding impairment of access to intersecting roadways and driveways from the improved facility. A detailed examination of the design schematics confirms that none of the Build Alternatives results in changes of access or likely alterations of neighborhood travel patterns from existing conditions. **Effects of Business Displacements on the Local Economy.** The anticipated displacement of businesses by the Build Alternatives could cause a decrease in city and school district tax revenues. The businesses anticipated to be displaced are a combination of highway-oriented businesses, offices, and larger retail stores dealing in appliances, farm supplies, and boats, among other examples (see **Section 3.4.4 Economic Characteristics**). Owners of displaced businesses would be fully compensated for the fair market value of their land and improvements, plus reasonable relocation assistance under federal and state law and procedures. It is likely that many of the potentially	No

Table 4-7: Summary of Encroachment-Alteration Effects Analysis

Resource and/or Issue	Potential Encroachment-Alteration Effects	Further Analysis in Step 6
Socioeconomic Resources (cont.)	displaced businesses would relocate to take advantage of available highway frontage locations. The economic effects of business displacements are considered to be short-term, with the magnitude depending on the length of time required to complete the ROW process and re-establish operations at the new facilities. **Effects on EJ Populations** Shorter term construction phase activities will have noticeable but temporary indirect effects on neighborhoods and commercial establishments along the project corridor. Both short and long-term socioeconomic encroachments and alterations have the potential to affect vulnerable populations, if they occur in nearby neighborhoods. The EJ analysis presented in **Section 3.4.3 Neighborhoods and Community Cohesion** identified several 2010 census blocks with EJ (minority) populations within the demographic study area, which is the same as AOI within Bexar County. The EJ analysis found that no commercial displacements required by the Build Alternatives would result in disproportionately high and adverse impacts to EJ communities. All of the Block Groups (2008-2012 American Community Survey) within the EJ/LEP Study Area had median household incomes substantially above the poverty level (**Appendix G, Table G-11**). For these reasons, encroachment alteration-effects on EJ or vulnerable populations would not be expected to occur. For the reasons discussed above, potential effects on local access and travel patterns, on the economic and employment effects of business displacements, and on EJ populations are not expected to be substantial, and these issues are not carried forward for analysis of encroachment-alteration impacts in Step 6.	No
Pedestrian and Bicycle Facilities	No pedestrian facilities (i.e. sidewalks) currently exist within the US 281 Corridor, except for crosswalks where US 281 Super Street has been constructed. There is one dedicated bike facility in the corridor at US 281 and Encino Rio. The Build Alternatives are not anticipated to have a substantial encroachment-alteration effect on existing or future pedestrian and/or bicycle facilities as future facilities are planned sans the proposed improvements to US 281. For these reasons, pedestrian and bicycle facilities are not carried forward for analysis of encroachment-alteration impacts in Step 6.	No
Transportation Mobility and Safety	Each of the Build Alternatives could have potentially substantial positive indirect effects on the mobility and safety of the transportation facilities in the project corridor. Mobility and safety issues are carried forward for further discussion in **Section 4.6.1 Encroachment-Alteration Effects**.	Yes
Air Quality - Conformity	Effective December 4, 2013, the San Antonio Air Quality Planning Area, which includes Bexar and Comal counties, is in an area designated as in attainment or unclassifiable for all NAAQS, including the 2008 ozone standard. Because the San Antonio Air Quality Planning Area is designated as Attainment/Unclassifiable for all NAAQS, air quality impacts to ozone, air quality conformity issues are not carried forward for analysis of encroachment-alteration impacts in Step 6.	No

Table 4-7: Summary of Encroachment-Alteration Effects Analysis

Resource and/or Issue	Potential Encroachment-Alteration Effects	Further Analysis in Step 6
Air Quality – MSAT	Indirect air quality impacts from MSATs are unquantifiable due to existing limitations in determining pollutant emissions, dispersion, and impacts to human health. Emissions would likely be lower than present levels in future years as a result of the EPA's national air quality regulations (i.e., new light-duty and heavy duty on-road fuel and vehicle rules, the use of low sulfur diesel fuel). Even with an increase in VMT and possible temporary emission increases related to construction activities, the EPA's vehicle and fuel regulations, coupled with fleet turnover, are expected to result in reductions of on-road emissions of MSATs and the ozone precursors VOC and NOx over time. For these reasons, air quality MSAT issues are not carried forward for analysis of encroachment-alteration impacts in Step 6.	No
Water Quality and Quantity	The Build Alternatives would add impervious cover and would involve downcutting, which could result in increased runoff, alter groundwater recharge and decrease water quality downstream of the project area. The increased runoff would affect the quantity of water that flows downstream. Runoff during rain events and flooding could indirectly lead to non-point source pollution (i.e., vehicle pollutants). This non-point source pollution has the potential to substantially affect the water quality of the Edwards and Trinity Aquifers, as well as karst recharge features and the surface waters located in and downstream of the US 281 Corridor. The Build Alternatives could encroach on the surface and subsurface drainage areas of adjacent sensitive recharge features by altering the hydrologic regime in those features. These changes could impact the flow and quantity of groundwater recharge. For these reasons, water quality and quantity issues are carried forward for further discussion in **Section 4.6.1 Encroachment-Alteration Effects**.	Yes
Floodplains	Each Build Alternative would increase impermeable surfaces and have the potential to indirectly affect sediment and pollutant loading in the 100-yr floodplain. However, floodplain management regulations and design standards would require that the Build Alternatives be designed so as not to alter base flood elevations and not cause adverse flood impacts to upstream or downstream properties. For these reasons, floodplains are not carried forward for analysis of encroachment-alteration impacts in Step 6.	No
Wetlands and Other Waters of the US	The Build Alternatives would encroach upon potential wetland areas that may be subject to USACE jurisdiction. These potential wetland areas are small and contained within the existing and proposed ROW, and would be subject to jurisdictional determinations and impact assessment once the Preferred Expressway Alternative is selected. For these reasons, wetlands and jurisdictional waters of the U.S. are not carried forward for analysis of encroachment-alteration impacts in Step 6.	No
Vegetation	Each Build Alternative would encroach upon vegetated areas along the US 281 Corridor via construction activities; however, construction activities are not anticipated to substantially impact existing vegetation. Furthermore, the vegetation cover types in the immediate project corridor are currently highly disturbed due to the existing roadway and the existing land uses. For these reasons, vegetation is not carried forward for analysis of encroachment-alteration impacts in Step 6.	No

Table 4-7: Summary of Encroachment-Alteration Effects Analysis

Resource and/or Issue	Potential Encroachment-Alteration Effects	Further Analysis in Step 6
Wildlife	Each Build Alternative would encroach upon vegetated areas along the US 281 Corridor via construction activities. These vegetated areas may provide habitat for terrestrial wildlife known to occur in the corridor. However, habitat in the corridor is highly disturbed to the existing roadway and the existing land uses adjacent to the highway, and any additional wildlife habitat fragmentation would be minimal. For these reasons, wildlife is not carried forward for analysis of encroachment-alteration impacts in Step 6.	No
Threatened and Endangered Species and Their Habitat	Habitat for four federally listed species (Madla Cave meshweaver, *Rhadine exilis, R. infernalis* and the GCWA) and one candidate species was identified within the footprint of each Build Alternative. Madla Cave meshweaver, *Rhadine exilis, R. infernalis* are known to occur in areas of suitable karst habitat located in the Stone Oak KFR of Bexar County. All existing known karst features within the project area have been surveyed for the presence of listed karst invertebrates and none where found. However, it is unknown if there are any additional karst features within the project area, although the presence of additional karst features is likely. If additional karst features are present, it also unknown if they are occupied. TxDOT determined that the proposed project *may affect and is likely to adversely affect* Madla Cave meshweaver, *Rhadine exilis, R. infernalis*. GCWA habitat exists along the US 281 ROW, although no birds were found after three years of survey, resulting in a *may affect, not likely to adversely affect* determination for the GCWA. For these reasons, threatened and endangered species issues are carried forward for further discussion in **Section 4.6.1 Encroachment-Alteration Effects**. Karst invertebrate surveys were conducted June 2010 through October 2010 (see **Appendix I2**). Avian surveys were conducted in spring 2009, spring 2010 and spring 2014 (see **Appendix I3**).	Yes
Cultural Resources - Archeological	No sites are listed or considered eligible for listing on the NRHP or as SALs within the APEs for the Build Alternatives, and archeological resource surveys confirmed that no previously unrecorded sites are located within the APE for either of the Build Alternatives; therefore, there would be no impact to known listed or eligible archeological properties. For these reasons, archeological resources are not carried forward for analysis of encroachment-alteration impacts in Step 6.	No
Cultural Resources - Historic	There are no known historic resources present within the APEs of the Build Alternatives, and historic resource surveys indicated that no previously unrecorded historic properties are located within the APE for either of the Build Alternatives; therefore, there would be no impacts to known historic resources. For these reasons, historic resources are not carried forward for analysis of encroachment-alteration impacts in Step 6.	No
Visual/ Aesthetic Resources	Each Build Alternative would have encroachment-alteration effects on the visual and aesthetic qualities of residences and commercial/retail establishments along the US 281 Corridor, as well as of the roadway facility. For these reasons, visual and aesthetic resources are carried forward for further discussion in **Section 4.6.1 Encroachment-Alteration Effects**.	Yes

Source: US 281 EIS Team, 2011

4.5.2 Induced Growth Effects

The US 281 Corridor Project is considering two Build Alternatives and a No-Build Alternative for mobility improvements along the US 281 project corridor. Each alternative would have varying effects on added vehicle trip capacity, reduced travel times, and increased accessibility to the area, which could make the area potentially more attractive to development overall. Many other development factors have to be taken into account as well, such as maturity of the existing transportation infrastructure; land availability and price; state of the regional economy; area vacancy rates; location attractiveness; political/regulatory conditions; land use controls; traffic volumes on intersecting roadways; and the availability of water and sewer infrastructure (NCHRP 2002).

In view of the complexity involved in making long term predictions about future land use development, the potential for induced growth related to the proposed US 281 improvements is substantial and **Section 4.6.2 Induced Growth Effects** provides qualitative and quantitative assessments of this type of indirect effect. The characterization of the extent and probable locations of potential induced growth was aided by a collaborative judgment effort using a panel of land use and development professionals, including officials from the local jurisdictions and water utilities within the AOI (see **Section 4.6.2 Induced Growth Effects**).

4.5.3 Effects Related to Induced Growth

Since induced growth effects are carried forward for more detailed study, effects related to induced growth are also reviewed in greater detail (see **Section 4.6.3 Effects related to Induced Growth** and **Table 4-21** in **Section 4.6.4 Evaluation of Analysis Results**). **Table 4-8** illustrates the screening analysis process for effects related to induced growth for various resources or issues and indicates whether or not the potential effects are carried forward for further analysis in Step 6.

Table 4-8: Summary of Analysis of Effects Related to Induced Growth

Resource and/or Issue	Potential Effects Related to Induced Growth	Further Analysis in Step 6
Land Use	The potential for future land use conversion from lower intensity uses to residential, commercial and other uses is addressed in **Section 4.6.2, Induced Growth Effects.** The Land Use Panel predicted that the Build Alternatives (Preferred Expressway Alternative, Elevated Expressway) could result in 18,574 to 19,096 acres of additional land becoming subject to potential development by 2035.	Land use not analyzed as a resource; related effects are addressed in subsequent categories
Farmlands	Agricultural lands and production in the AOI are composed mostly of native rangelands, with predominant shallow limestone and calcareous soils. Limited crop farming occurs in the deeper soils along the larger stream basins; crops have largely given way to improved pastures and other forage grasses in recent years.	No

Table 4-8: Summary of Analysis of Effects Related to Induced Growth

Resource and/or Issue	Potential Effects Related to Induced Growth	Further Analysis in Step 6
Socioeconomic / Community Resources	Communities within the identified induced growth area would be subject to accelerated urban development and may experience changes in historic social, economic, and aesthetic characteristics. Updated demographic analysis based on 2010 Census and 2008-2012 American Community Survey data indicates minority, low income, elderly, or other potentially vulnerable elements of the population have not changed substantially since 2000. While effects to socioeconomic resources (including EJ populations) related to travel patterns, access or displacements would occur as a result of the Build Alternatives, induced growth effects related to the proposed project would have the potential to result in changes to community cohesion and quality of life. Therefore, Community Resources are discussed further in Step 6.	Yes
Pedestrian and Bicycle Facilities	The proposed project improvements would provide pedestrian and bicycle facilities within the footprint of the US 281 Corridor Project. None of the outlying communities have organized pedestrian or bicycle facilities.	No
Air Quality	As of December 2013, the San Antonio air quality region, which includes Bexar and Comal counties, is in an area designated as in attainment or unclassifiable for all NAAQS including ozone. The US 281 Corridor Project is included in *Mobility 2035* (see **Section 3.7 Air Quality**). The potential development/land use modifications identified as indirect effects of the US 281 Corridor Project would not involve activities likely to substantially affect regional ozone emissions or the conformity status of the US 281 Corridor Project. A quantitative MSAT analysis was completed after selection of the Preferred Expressway Alternative and documented in the Final EIS (see **Section 3.7 Air Quality**). Regulatory emission limits set by TCEQ and EPA are established to attain and maintain the NAAQS by assuring any emissions sources resulting from new development or redevelopment will not cause or contribute to a violation of those standards. Regulatory emission limits set by TCEQ and EPA are established to attain and maintain the NAAQS by assuring any emissions sources resulting from new development or redevelopment will not cause or contribute to a violation of those standards.	No
Water Resources/ Water Quality and Quantity	Surface water quality and quantity is identified as a potentially substantial effect of induced growth, with focus on currently undeveloped or sparsely developed areas within the Upper Guadalupe watershed. Groundwater quality and quantity is of concern in the face of all potential development within the AOI, but only a small fraction of the Edwards Aquifer Recharge Zone intersects with the identified US 281 induced growth area.	Yes
Wetlands	Wetlands are not extensive within the induced growth area but are considered in the context of valuable river corridors like the Upper Guadalupe. Wetlands and other waters of the U.S. are protected to some extent by existing regulations under the Clean Water Act and Executive Order 11990.	No
Vegetation and Wildlife Habitat	Vegetation within the induced growth area is mostly characteristic of rangeland, with valuable native vegetation and wildlife habitat along riparian corridors. These resources are considered within the overall category of Ecological Resources.	Yes

Table 4-8: Summary of Analysis of Effects Related to Induced Growth

Resource and/or Issue	Potential Effects Related to Induced Growth	Further Analysis in Step 6
Threatened and Endangered Species and Their Habitat	Of the listed species known to occur within the AOI, GCWA habitat is most prominently identified within the induced growth area. The ecological effects analysis focuses on habitat identified by current GCWA habitat models that may be subject to induced growth. There is no known occupied habitat for federally-listed karst invertebrates within the induced development area, therefore, no impacts are anticipated.	Yes
Floodplains	Floodplains are considered in the context of Water Resources and Water Quality. Development in floodplains is limited by regulatory provisions under the National Flood Insurance Program and Executive Order 11988.	No
Cultural Resources	Private development activities within the AOI would not be subject to cultural resources regulatory protection, and potentially significant undiscovered cultural resource sites could be adversely affected. Due to uncertainties about the magnitude of these effects and their causal relationship to the project, these indirect effects are considered possible but not probable, and are not further addressed.	No
Visual/ Aesthetic Resources	Urban development would inevitably result in changes to the visual environment, as experienced primarily by residents of affected communities. Aesthetic impacts are addressed within the category of Community Effects.	Yes, as part of Community Effects

Source: US 281 EIS Team, 2011

4.5.4 Summary of Potentially Substantial Effects

Step 5 is intended to screen potentially substantial indirect effects to determine those which require more in-depth assessment. The analysis concluded that the Build Alternatives may have substantial encroachment-alteration effects on surface and groundwater quality and quantity, threatened and endangered species, and visual and aesthetic resources. The mobility improvements resulting from the proposed roadway improvements are also considered likely to induce residential and commercial land development within the AOI.

As suggested by the indirect effects guidance documents (TxDOT 2010e; NCHRP 2002), the decision to focus the indirect effects analysis on these encroachment-alteration effects and the effects related to potential induced development has been made in the context of: (1) notable features or resource issues, (2) the type and extent of impacts of project activities, and (3) the relative importance of those resource-impact interactions in light of community environmental and development priorities, as expressed by goals and planning documents of public agencies and organizations in the region.

These factors contribute to the prioritization of indirect impacts in the following ways:

(1) The most important notable features within the AOI, based on the analysis described in detail in Step 3, are surface and groundwater as it pertains to water quality, particularly in the Upper Guadalupe River and the Edwards Aquifer; and threatened and endangered species, especially karst invertebrate habitat in Bexar County and GCWA habitat in Comal, Bexar, and Kendall counties. Other notable features include the remaining agricultural lands within the AOI, the characteristic karst geology of the region, Guadalupe State Park and other parks

and trails, the city of San Antonio and the smaller communities to the north, and Camp Bullis.

(2) Impact-causing activities typically associated with roadway construction include removal of vegetation, exposure of soil, expansion of impervious cover, and longer term changes in access or travel patterns and improved mobility due to increased roadway capacity. Changed access and improved mobility are likely to result in induced land development, which would entail geographical expansion or an accelerated rate of home and commercial building, with accompanying roadway and infrastructure construction. This induced growth will result in likely (although not precisely quantifiable) encroachment and/or alteration effects associated with the large scale conversion of land uses from open space, rangeland, or undeveloped land to residential and commercial uses.

(3) Most of the plans and goals of area agencies or jurisdictions deal directly with the characteristic conflicts between highly-valued natural resources and the developmental demands of a growing economy (discussed in **Section 5.3.2 Socioeconomic and Community Resources**). These goals and plans in most cases represent the integration of professional planning expertise and an expression of the desires of the public about important resource protection and growth management issues.

To cite just a few examples from the synopses of goals and plans presented in **Section 4.2 Step 2: Identify the Study Area's Goals and Trends** protection of the long term environmental and economic values of surface and groundwater resources is a primary goal shared by the EAA, Guadalupe-Blanco River Authority, and the Region L Water Plan. Ecological goals are centered on the federally-listed threatened or endangered species which are concentrated in the Southern Edwards Plateau-Balcones Fault Zone region. The goals for protection of the GCWA, karst invertebrates, and aquifer and spring species within the regulatory framework of the Endangered Species Act are outlined in the recovery plans and habitat conservation plans for those species. Achieving a sustainable balance between economic and environmental values is also the mission of the organizations charged with planning and managing development and land use in the region. For example, the City of San Antonio's North Sector Plan emphasizes the reduction and mitigation of flood hazards by increasing storm water percolation while at the same time promoting improved mobility and connectivity on the street and roadway network in the sector. *Mobility 2035* lays out a set of transportation goals in a regional context that seeks to foster appropriate land use patterns and to "recognize the uniqueness of San Antonio, ensuring respect for neighborhoods, historic and archeological resources, the Edwards Aquifer, and other social and environmental issues" (SA-BC MPO 2009). Local governmental and non-governmental organizations have mutually acknowledged the economic and environmental assets of Camp Bullis and established appropriate protective goals and strategies. These plans and goals represent the evolving perceptions of the population as they relate to the uniquely valuable but increasingly threatened natural assets of the region. Together they establish a context for the more in-depth examination in Step 6 of the substantial indirect effects within the AOI that may be associated with the proposed US 281 improvements.

These effects include:

- Encroachment-alteration effects
    - surface and groundwater quality and quantity
    - karst features
    - threatened and endangered species, and
    - visual and aesthetic resources
- Induced growth effects
- Effects related to induced growth including:
    - water resources
    - community resources
    - surface and groundwater quality and quantity
    - threatened and endangered species
    - state-listed species
    - vegetation and wildlife habitat

4.6 STEP 6: ANALYSIS OF INDIRECT EFFECTS AND EVALUATE RESULTS

The purpose of this step is to further assess the potentially substantial indirect effects identified in Step 5 by determining the magnitude, probability of occurrence, timing, duration and degree to which the effects can be controlled or mitigated. Step 5 concluded that there are potentially substantial encroachment-alteration effects, induced growth effects, and effects related to induced growth in the AOI that merit further consideration.

4.6.1 Encroachment-Alteration Effects

This step in the analysis will assess the magnitude of and the degree to which potential encroachment-alteration effects can be controlled or mitigated for previously identified resources. Further, and as the guidance documents suggest, describing the assumptions and limitations used in this analysis is important to understanding the causal relationships between proposed actions and the reasonably foreseeable future effects of those actions.

Transportation Mobility and Safety

Construction of any of the Build Alternatives could result in substantial positive indirect effects to the mobility and safety of the transportation facilities located within the US 281 project corridor. As stated in **Section 1.4 Purpose of the Proposed Action**, part of the primary purpose of each of the Build Alternatives is to improve mobility and accessibility and to enhance safety. Improvements to the existing corridor would reduce travel time and increase travel speeds, reduce conflicts between local and through traffic, and improve access to adjacent properties. Reduced crash rates would be expected as a result of improved mobility within and through the corridor. These benefits would be expected to accrue for residents and commercial enterprises within the AOI who are users of the US 281 Corridor Project.

Water Resources

Groundwater Quality and Quantity

Edwards Aquifer. The Build Alternatives would be constructed over the Recharge and Contributing zones of the Edwards Aquifer. The Recharge Zone is where large quantities of water flow into the aquifer. According to the EAA, approximately one-half of recharge occurs when streams and rivers traverse the Recharge Zone and streamflow goes underground. The balance of recharge occurs when rain falls directly on the Recharge Zone and surface runoff enters upland recharge features. The Contributing Zone is the drainage area of the aquifer where the land collects water which runs off into streams that recharge the aquifer as they cross the Recharge Zone. Of the approximately 7.3 miles of the proposed US 281 project corridor, a majority (approximately 6.2 miles) of the proposed improvements to US 281 would occur in the Recharge Zone and approximately 1.7 miles would occur in the Contributing Zone. There are 10 sensitive karst features indicating the potential to recharge groundwater directly to the Edwards Aquifer within 500 feet of the proposed ROW for US 281 Corridor Project (Zara 2011). The Build Alternatives could result in encroachment-alternation impacts to recharge features outside the proposed ROW by modifying the surface and subsurface. Removal of vegetation causes an increase in runoff flow velocity and siltation, which negatively impacts water quality of runoff and may decrease recharge in the future by clogging recharge features with silt and clay. The placement of compacted fill may decrease recharge by altering surface flow paths and directing recharge away from features. The addition of impervious cover would prevent water from infiltrating downward into the aquifer. Subsurface impacts include severing karst conduits due to cuts and fills with compacted materials. Severing a conduit may inadvertently reduce flow to nearby features by preventing groundwater from entering or exiting the main body of the aquifer, and/or redirecting groundwater flow in a way that causes it to be isolated.

As discussed in Step 5, increasing impervious cover via construction of a larger transportation facility has the potential to add non-point source pollution to areas of the aquifer that are vulnerable to pollutant inflows. And, as discussed in **Section 3.9 Water Quality**, karst aquifers are highly susceptible to contamination due to rapidly transmitting surface water into the subsurface through systems of enhanced permeability channels, which include solution-enlarged fractures or joints, faults, solution cavities, solution sinkholes, collapse sinkholes, caves, or combinations of these features. The magnitude of the potential indirect impact of increased road pollutant loads would be greatest in the Preferred Expressway Alternative (86 additional acres) and the Elevated Expressway Alternative (83 additional acres) and would present the greatest potential for indirect effects due to the largest amount of introduced or additional impervious cover (larger transportation facility) into the Recharge and Contributing zones. Pollutants such as petroleum products (i.e., motor oil and gasoline) and dissolved metals from vehicles using US 281 can collect on impervious surfaces and, over time and in between rain events, become concentrated. Subsequent to rain or flood events, these pollutants would be washed into corridor streams, which would channel runoff into aquifer recharge and contributing areas.

Edwards Aquifer Discharge. There is the potential for spring water quality impacts due to contamination from a spill in the US 281 project corridor or from continual impacts from normal highway usage. Springs west of Bexar County are unlikely to be impacted because the flowpaths in the Edwards Aquifer generally move eastward. There is the potential for water quality degradation at any spring located east of the US 281 project corridor due to continual impacts from normal highway usage or if spills or leaks occur along the highway; however, the proposed improvements may result in a net benefit to spring water quality. The US 281 project corridor currently has unpaved and informal shoulders and does not have a storm water drainage system that meets current Edwards Aquifer Rules. The proposed improvements include a storm water drainage system that meets TCEQ standards and measures to trap potential contaminant spills before they can enter the aquifer. This design will likely increase the quality of water discharged from the roadway and minimize the potential for spills or leaks to enter the aquifer.

San Marcos Springs is thought to receive most of its water from an area to the southwest extending into Comal County west of New Braunfels and an area extending to the northeast into Hays County. San Marcos Springs would likely be minimally impacted by activities directly related to US 281 due to the distance that water must travel through the aquifer to reach the springs. A small portion of the area of potential future development induced by the proposed improvements occurs in the Edwards Aquifer Recharge Zone and could impact water quality at San Marcos Springs; however, the majority of the area of projected future development occurs in the Edwards Aquifer Contributing Zone and is unlikely to impact San Marcos Springs. Hueco Springs, located approximately two miles north of Comal Springs in Comal County, recharges from western Comal and northern Bexar Counties, and could be impacted if a major contamination event occurred.

Comal Springs, which is the largest spring in Texas and less than 20 miles from the US 281 project corridor, is the major discharge point for flowpaths that recharge the Edwards Aquifer near the project corridor. The potential indirect impacts on the water quality at Comal Springs are likely to be small, particularly due to TCEQ's Edwards Aquifer Rules for development within the Contributing and Recharge Zones of the Edwards Aquifer that require temporary and permanent best management practices (BMPs) that capture and remove a minimum of 80 percent of the increase in TSS generated by new impervious cover (TCEQ 2005). The US 281 Corridor Project will meet 80 percent TSS removal for the project as a whole, by meeting the 80 percent TSS removal threshold at each storm water outfall. Therefore, no storm water runoff leaves the project without first passing through a temporary BMP (during construction) or a permanent BMP (after construction) to remove the necessary pollutant load. Water quality impacts from the project will likely be minuscule when compared to the cumulative impacts to water quality caused by urbanization in the entire San Antonio region. The greatest impact to the water quality in Comal Springs could come from a major contaminant spill caused by an accident on US 281. It is possible that a spill could result in the rapid infiltration of contaminants into the aquifer via karst features (potentially unidentified) and that the contaminants cold be rapidly transported to wells and springs, including Comal Springs.

Unlike sandy or alluvial aquifers, rapid flow through karst conduits does not afford much opportunity for degradation of contaminants by natural processes; however the convergent nature of karst groundwater flow can dilute contaminant plumes somewhat before reaching a discharge point, particularly along longer flow routes. In the Edwards Aquifer, groundwater flow is analogues to flow in a river system. Smaller flowpaths continually converge forming larger flowpaths until forming a major flowpath that capable of transport large quantities of water over long distances in a short period of time. These major flowpaths typically discharge at large springs as is the case with Comal Springs. The convergent flow regime can sometimes lead to significant dilution of contaminant plumes and decreases in contaminant concentration, but dye tracing studies in the Edwards Aquifer show that tracer plumes are typically attenuated very little and that their arrival and persistence is often short-lived. Any amount of contaminants from potential spills, construction, or cumulative operation could degrade the overall quality of the spring water. Of all the springs in the Edwards Aquifer, Comal Springs has the highest potential for impact and water-quality degradation from any activities in northern Bexar County.

Wells are constructed to withdraw water from an aquifer for a variety of uses, such as public supply, agricultural, domestic, stock, industrial or mining. Public supply is the highest use category and is centered on the major metropolitan areas. Irrigation use is second and is predominantly located in western Uvalde and Medina counties. Wells are discharge points for water from the aquifer and can act to bring subsurface contaminants back to the surface where they could come in contact with people or be consumed. Wells located down-gradient of the US 281 project corridor are susceptible to contamination just as springs are, and could be impacted far more rapidly and with greater concentrations of any pollutant introduced to the aquifer.

There are 12 water supply wells and 3 springs within 500 feet of the proposed ROW for US 281 Corridor Project (Zara 2011). The construction activities that could result in encroachment-alternation impacts to recharge features may also impact discharge features. Modifying surface and subsurface water flow regimes could reduce the both the quantity and quality of discharge features outside the proposed ROW.

Trinity Aquifer. As described in **Section 3.9 Water Quality**, the northern-most extent of the US 281 project corridor is the most utilized portion of the Trinity Aquifer in Bexar County. In this area, which is the middle unit of the Trinity, the aquifer is found approximately 500 to 1,000 feet below Edwards limestone and the primary recharge is Cibolo Creek. The Trinity Aquifer in this location can be considered sensitive due to interconnectedness with the Edwards Aquifer Recharge Zone and is susceptible to the same potential encroachment-alteration effects to water quality as the more southern areas of the US 281 project corridor.

Karst Features

As described in **Section 3.16 Threatened and Endangered Species**, 48 caves or potential karst features have been identified in the existing ROW. The Elevated Expressway Alternative would impact 54 karst features and the Preferred Expressway Alternative would impact 57 karst features. It is difficult to predict the magnitude of potential encroachment-alteration effects to karst features which could include habitat; however, based on previous studies, a prediction can be made as to the types of potential indirect impacts that may be due to each of the Build Alternatives. **Table 4-9** shows the acreage within the AOI of the five Karst zones.

Table 4-9: Karst Zone Acreage within the AOI

Karst Zone	Acres
1	18,882
2	40,499
3	42,697
4	0
5	28,484

Source: US 281 EIS Team, 2011.

Viable karst habitat is dependent on stable temperatures, high humidity and nutrients (for example from leaf litter) that enter from the surface. The proposed project may result in indirect impacts to karst invertebrate habitat from surface disturbances such as vegetation removal, which may result in alterations in nutrient input and outflow and the introduction of invasive species. Other indirect effects to karst invertebrate habitat may occur within and adjacent to the project area due to the placement of impervious cover (bridge decks, roadway surfaces, etc.) which could increase chemical runoff or erosion and alteration in surface and subsurface drainage that may result on short and long term changes to temperature and moisture regimes in karst habitat. Decreases in the flow of water or infiltration can result in excessive drying and may hinder decomposition, while increases can cause flooding that drowns air-breathing species and carries away available nutrients (USFWS 2011). In addition, alterations to surface topography, including decreasing or increasing soil depth (i.e. cuts) or adding non-native fill, can change the nutrient flow into karst habitats (USFWS 2011).

Changes in the physical environment beneath a newly constructed road can create edge effects that extend beyond the construction timeframe. One of the edge effects is the reduction in water vapor transport into and out of the natural environment caused by the addition of impervious surfaces or roadways. Natural surfaces, especially those with vegetation, use heat energy for evapotranspiration of water, effectively cooling themselves; roadways store heat energy, raising the surface temperature of the roadway, and raising the temperature and lowering the humidity of the area immediately adjacent to the roadway (Barnes et al. 2012). Roadway materials, such as dark asphalt pavement, are thermally conductive, meaning they have the ability to absorb more heat and rapidly move it into the ground beneath the road surface. Heat stored by roadways is released at night, creating a heat island when compared with surrounding soil or vegetation (Trombulak and Frissell 2000). Roadway heat islands exacerbate subsurface impacts to temperature and moisture by perpetuating drying conditions.

Surface Water Quality and Quantity

US 281 is designated as a through-traffic hazardous cargo route; thus, in addition to non-point source pollution (i.e., motor oil) potentially entering the aquifers via storm runoff, a larger and improved transportation facility would increase the probability of hazardous material spills due to accidents (such as rollovers) involving cargo trucks. Hazardous material runoff could substantially degrade the water quality of impacted streams and portions of the Edwards and Trinity aquifers within and adjacent to existing and proposed ROW; especially after storm events. Karst aquifers are well documented to rapidly transmit surface water into the subsurface through systems of enhanced permeability channels, such as sinkholes, faults and caves; thus, should a spill occur on US 281, it could substantially impact water quality in a short time period based on the porosity and interconnectedness of the aquifers.

The 2007 Cargo Tank Rollover Stability Study analyzes the characteristics that contribute to cargo tank rollovers throughout the nation. This study sources four national datasets for its analysis; the Motor Carrier Management Information System, the Large Truck Causation Study, and the Trucks Involved in Fatal Accidents, provided by the Federal Motor Carrier Safety Administration, and the General Estimates System which is provided by the National Highway Traffic Safety Administration. According to the findings in the 2007 study, 75 percent of cargo tank rollovers occurred as a result of driver error of one kind or another, approximately 15 percent were due to inattention and distractions, and 5-10 percent were due to evasive maneuvers. In addition, 85-90 percent of rollovers occurred on dry pavement. Out of 237 rollovers, 68.8 percent occurred on undivided highways and out of 1,265 rollovers, 47.4 percent were due to trucks running off the road or colliding with other vehicles. Further, approximately 25 percent of rollovers occurred on a US highway and approximately 36 percent occurred on a state highway with most rollovers occurring in rural settings (USDOT 2007).

As it exists now, the US 281 project corridor is classified as a divided, urban principal arterial in the south and a divided, rural principal arterial to the north, from Stone Oak Parkway to Borgfeld Drive. In addition, the current facility has unpaved and informal shoulders along the entire corridor from Loop 1604 to Borgfeld Drive. The existing roadway also does not have a storm water drainage system that meets current Edwards Aquifer Rules, which is required for any regulated activity proposed on the Edwards Aquifer Recharge Zone, such as the construction of roads and highways. For these reasons, existing conditions of the US 281 project corridor are such that any hazardous spill from cargo truck accidents may not be well-contained. Conversely, each Build Alternative would involve the construction of storm water drainage facilities (i.e. detention and retention ponds), in accordance with TCEQ policies and rules, that would better capture and contain potential hazardous materials spills, assuming the pavement has dry conditions. In effect, the increased impervious cover from each Build Alternative would act as a capture basin from potential spills; whereas, the existing facility would most likely not contain spills to the same degree. However, this assumes that the pavement is dry on the existing facility and no rain events occur subsequent to a spill. During a rain event, a hazardous spill has the potential to spread and travel at a faster rate into storm water facilities making it more difficult to contain.

Impervious cover prevents water infiltration into the ground, thereby reducing the amount of water that stays on site and increasing the amount of water that flows off site; some of which would flow into surface waters downstream. The water quality BMPs proposed for the US 281 Corridor Project would only have the effect of slowing the rate at which water flows off site but not the quantity.

Threatened and Endangered Species and Their Habitat

As described in **Section 3.16 Threatened and Endangered Species**, potential habitat for the federally-listed (Madla's Cave meshweaver, the ground beetles *Rhadine exilis* and *Rhadine infernalis*, and the GCWA) and candidate (bracted twistflower) species was identified within the footprint of each Build Alternative; however, none of these species were found during surveys of the existing and proposed ROW (karst invertebrate surveys were conducted between June and October 2010 and avian surveys were conducted in spring 2009, spring 2010 and spring 2014).

No GCWAs have been detected after three years of presence/absence surveys. However, it is possible for encroachment-alteration effects to occur in areas where there is habitat, which is mainly in the northwest portion of the US 281 project corridor, south of Borgfeld Drive. The magnitude of this type of potential indirect impact on the GCWA is expected to be minimal; however, existing and continued development, effects from predators and parasite species, and the general degradation of habitat quality is likely to impact the GCWA.

The Madla's Cave meshweaver and the ground beetles *Rhadine exilis* and *Rhadine infernalis* are obligate cave species, or "troglobites." They have small geographic ranges and are limited to a particular geographic area (Porter 2007; Christman et al. 2005). The physical factors in caves and karst features that affect life history of troglobites include lack of sunlight, low nutrient flow (due to lack of primary production), and a stable environment with uniform temperature and humidity (USFWS 2011). As such, disturbances to these physical factors may adversely affect the stable environment in which these species have evolved. Currently, very little is known about the ecology of these species; however, they are known to be top predators in their ecosystem (USFWS 2011) and are dependent on the stability of the prey base that makes up the lower trophic levels of the karst ecosystem (Taylor et al. 2005).

Habitat degradation from short and long term changes to temperature, humidity, and moisture regimes in karst habitat, groundwater contamination, changes in nutrient input or an increase in invasive species may result in take of listed karst species. These habitat degradations could also result in harassment if they result in the disruption of essential behavioral patterns, such as breeding, feeding or sheltering.

The closest known location for *R. infernalis* is Genesis Cave, which is 1.7 miles west of the proposed project, and the only known location for *C. madla* in the Stone Oak karst faunal region is located about seven miles west of the project area. *R. exilis* is the only listed karst species known to occur adjacent to the project area. It is known to occur in both caves making up critical habitat unit (CHU) 12. CHU 12 is heavily impacted by residential development within its boundaries. Alterations to the surface and subsurface drainage basins have occurred during residential development due to the addition of impervious cover for the construction of roads and houses, changes to the surface vegetation from native plants to lawn grass and ornamental flowers and shrubs, and subsurface alteration for utility installation and drainage. The adjacent limestone quarry, to the south, and significant urbanization surrounding CHU 12 also likely contribute to the lower quality of the CHU. The entrances to both caves in CHU 12 are at higher elevations that the adjacent ROW and their surface drainage basins do not extend into the ROW. Modifications to the ROW may indirectly affect the CHU due to hydrologic changes in nutrient flow or water quality through the subsurface drainage basins. However these potential effects are unlikely because the deepest mapped elevation of Ragin' Cajun Cave is at a slope of about five degrees below the final down-cutting grade of the proposed US 281 and the deepest mapped elevation of Hairy Tooth Cave is completely up gradient of the proposed project grade. It is unlikely that water or nutrients entering the subsurface as a result of downcutting with the US 281 ROW would maintain a shallow enough descent to affect either cave in the CHU.

It is extremely difficult, if not impossible, to determine the response of *C. madla, R. exilis* and *R. infernalis* to the proposed action. Surface surveys have been conducted for karst habitat and all potential karst features found in the pre-project survey were investigated. There are no known karst features within the proposed construction area that contain listed species. Since any karst habitat that would be affected by this action does not have a surface connection, there is no cave cricket foraging area to be altered by surface vegetation clearing. *R. exilis* exists in the two caves that occur in CHU 12, located in a residential subdivision adjacent to the proposed US 281 ROW. The surface drainage basins for both caves are at higher elevations than the proposed project; therefore, they would not be altered or affected by the proposed project, either directly or indirectly. The subsurface drainage basins are not currently known, so it may be possible that *R. exilis* could be indirectly affected if the project actions modify nutrient and water inputs or introduce contaminants into the subsurface drainage basins.

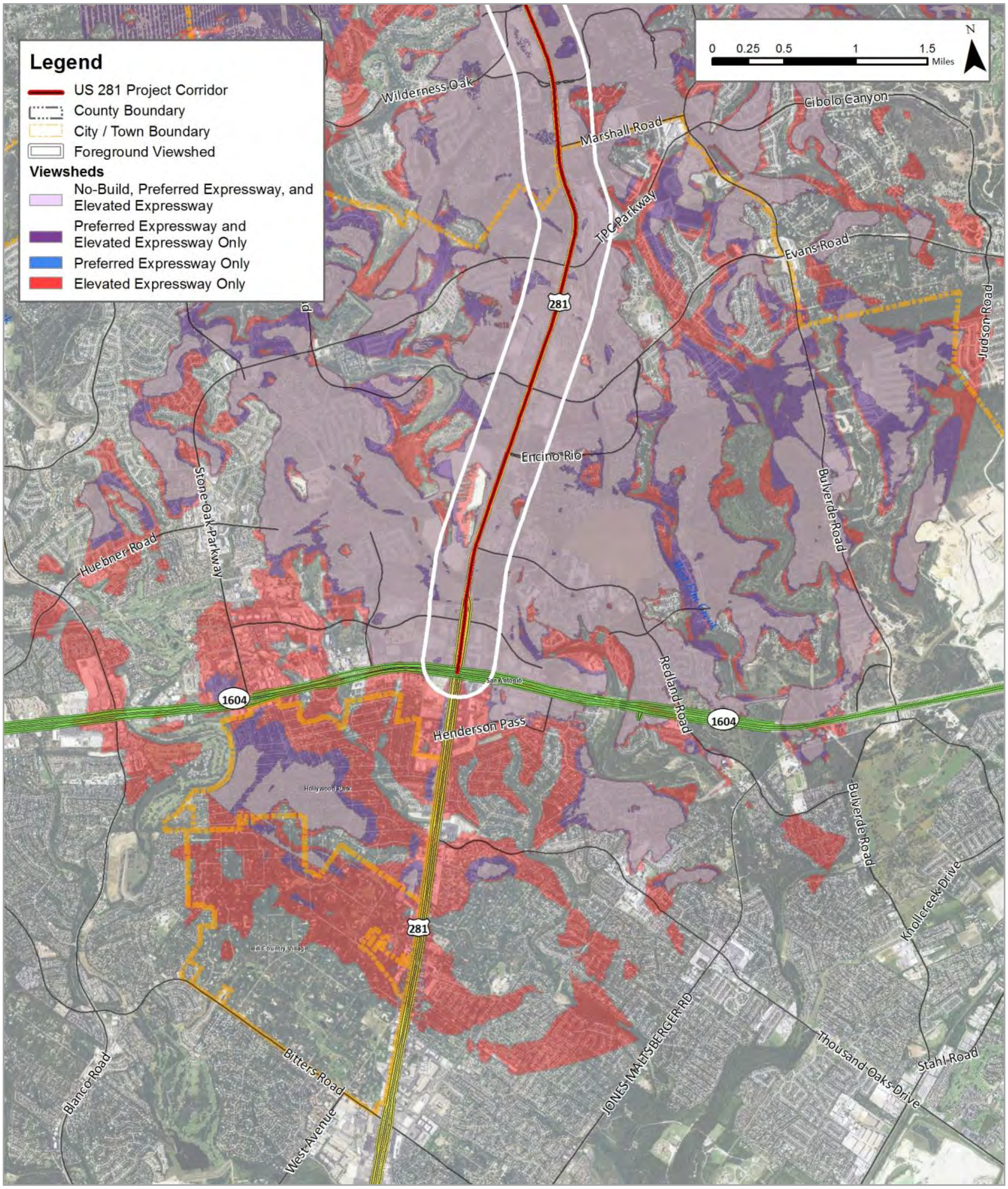
Visual and Aesthetic Qualities

Visual and aesthetic qualities are subjective in nature and are highly dependent on the roadway user and viewer's opinion on what constitutes high-value visual and aesthetic qualities. Indirect effects on visual and aesthetic quality focus on the relationship between the proposed action and the resulting visual and aesthetic changes which could occur later in time or further away in distance from the direct effects of the action. This analysis focuses on the effects to residential roadway viewers because they are generally more sensitive to change than roadway users. It is assumed that a roadway user would experience a positive effect as a result of the Build Alternatives because their viewshed would be wider and would offer a greater view of the surrounding landscape, whereas a roadway viewers' viewshed could be diminished with a more pronounced and/or new view of roadway infrastructure.

The same methodology and assumptions used in **Chapter 3 – Affected Environment** (see **Section 3.20 Visual and Aesthetic Qualities**) were used to calculate the potential number of residential roadway viewers that could experience indirect visual and aesthetic effects. As stated in **Chapter 3 – Affected Environment and Environmental Consequences**, the numbers of affected residential properties are overestimations and were used for comparison purposes only.

According to FHWA guidance, there are three distinct viewing distances, foreground (0 to 0.25 mile from the roadway), middleground (0.25 to 3 miles from the roadway) and background (greater than 3 miles from the roadway). Potentially substantial encroachment-alteration effects that occur later in time would most likely adversely affect roadway viewers located in the foreground because they would have the greatest exposure to the change. The middle and background roadway viewers would have less exposure and sensitivity to the change when compared to the foreground viewers and would experience indirect encroachment-alteration effects because they are further away in distance from the US 281 project corridor. **Figure 4-5a** and **Figure 4-5b** show the viewsheds of the Build Alternatives and the No-Build Alternative.

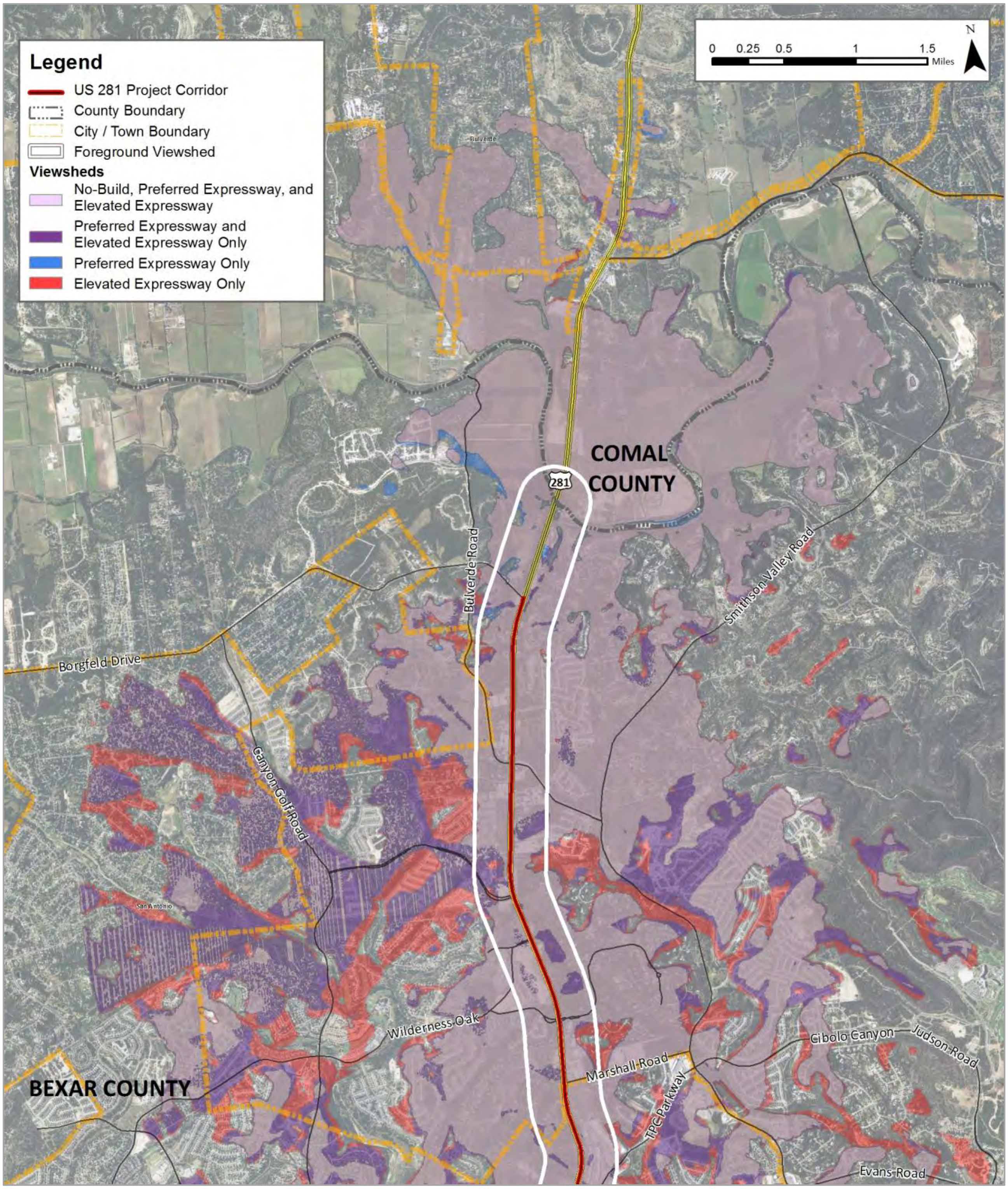
1 **Figure 4-5a: Viewsheds – South of Marshall Road**



2

3 Source: US 281 EIS Team, 2014

Figure 4-5b: Viewsheds – North of Marshall Road



Source: US 281 EIS Team, 2014

There are several residential neighborhoods and apartment complexes as well as large lot residential properties located within the foreground, middleground and background viewsheds:

- Redland Ridge neighborhood
- The Ravina Apartments
- Encino Park neighborhood
- Big Springs neighborhood
- Villages at Encino Park neighborhood
- Stone Oak neighborhood
- The View at Encino Commons (Apartments)
- Cavalo Creek Estates neighborhood
- Oakridge Heights neighborhood
- Encino Ridge neighborhood
- Evans Ranch neighborhood
- Winchester Hills neighborhood
- The Oaklands neighborhood
- Mountain Lodge neighborhood
- Sendero Ranch neighborhood
- Summerglen neighborhood
- Lookout Canyon neighborhood
- Belterra neighborhood
- Tuscan Oaks neighborhood
- The Estates of Stonegate neighborhood
- Trinity Oaks neighborhood
- Large lot residential properties north of Bulverde Road

Marked visual changes as a result of the Preferred Expressway Alternative would occur where the roadway would be vertically elevated approximately 25 to 35 feet at proposed overpasses (Redland Road, Encino Rio, Evans Road, Stone Oak Parkway, Marshall Road, Wilderness Oak, Overlook Parkway, Bulverde Road and Borgfeld Drive) and at the US 281/Loop 1604 interchange direct connectors. As shown in **Table 4-10**, an approximate total of 17,070 residential properties (805 in the foreground and 16,265 in the middle- and background) could experience adverse encroachment-alteration effects. This means approximately 3,450 more residential properties would be exposed to US 281 roadway over the No-Build Alternative.

The Elevated Expressway Alternative proposes an elevated structure adjacent to the existing roadway at an average height of 25 feet for the entire length of the corridor, from Loop 1604 to Borgfeld Drive; this structure could be up to 60 feet tall where on and off ramps are proposed. The areas where the Elevated Expressway Alternative would reach approximately 60 feet in height include: between Stone Oak Parkway and Marshall Road, between Mountain Lodge and Summer Glen, between Overlook Parkway and Bulverde Road, and between Bulverde Road and Trinity Park. The Elevated Expressway Alternative could adversely affect 815 residential properties in the foreground and 24,040 in the middle- and background; for a total of 24,855 residential properties (**Table 4-10**). The Elevated Expressway Alternative could affect approximately 11, 235 more residential properties than the No-Build Alternative and 7,785 more than the Preferred Expressway Alternative. Four residential neighborhoods, (Mountain Lodge, Tuscany Heights, Lookout Canyon Creek and Trinity Oaks), could experience the greatest indirect impacts from the Elevated Expressway Alternative due to their proximity to the 60-foot segments of the elevated structure.

Table 4-10: Number of Residential Properties Indirectly Affected

Alternative	Potential Affected Residential Properties		
	Total	Foreground	Middleground & Background
No-Build	13,620	795	12,825
Preferred Expressway	17,070	805	16,265
Elevated Expressway	24,855	815	24,040

Source: US 281 EIS Team, 2014

Potential indirect adverse impacts to roadway viewers may include a decreased sense of aesthetic value. These potential encroachment-alteration effects may be more pronounced at night if roadway lighting intrudes into windows facing the roadway, potentially amplifying a decrease in aesthetic value. It is expected that these effects would be more pronounced for roadway viewers located in the foreground than those located in the middle- and background.

Some of adverse visual and aesthetic effects may be mitigated or minimized, where practicable, through landscaping and aesthetic treatments. All lighting for the Build Alternatives will meet or exceed the "full cutoff" criteria within the Camp Bullis Military Lighting Overlay District (no light shall be emitted above 90 degrees at any lateral angle around the fixture), per the City of San Antonio's City Code and Bexar County Commissioners Court's Regulation. As discussed in **Section 3.20 Visual and Aesthetic Qualities**, aesthetic treatments would be included as part of the Preferred Expressway Alternative. The TxDOT San Antonio District has identified urban design themes for the majority of Bexar County, each based on a unique aesthetic concept aimed at creating regional identify and interest within the San Antonio area. The proposed project is located in the Hill Country Region, which encompasses the north and west regions of San Antonio outside of IH 410. This aesthetic concept consists of simple materials intended to translate the historical architecture of Hill Country towns into modern highway structures. See **Section 3.20 Visual and Aesthetic Qualities** for more information regarding the Hill Country Theme and the potential mitigation effects of its implementation.

4.6.2 Induced Growth Effects

Estimating Induced Development: Collaborative Judgment Panel Process

To forecast indirect land use effects of the proposed project, the US 281 EIS Team invited a group of individuals with expertise in land use and development within the AOI to participate in a collaborative judgment Land Use Panel. The panel was comprised of planners, engineers, school district officials, land appraisers, non-government organization leaders, and other individuals with demonstrated knowledge in growth and development in the area who were willing to lend their time and expertise. The composition of the Land Use Panel was intended to include people with substantial local knowledge about individual properties, particular land parcels, local zoning and real estate conditions, and environmental issues in the area. The group was intended to reflect diverse approaches to land use and development issues, drawn from the fields of academia, real estate, land use, transportation and policy planning, and economics, as well as informed lay persons. The methods for selecting panel members and implementing the collaborative judgment land process derived from a number of transportation planning sources (AASHTO 2002, AASHTO 2007, TxDOT 2010e). Participants in the Land Use Expert Panel are listed in **Table 4-11**.

Table 4-11: US 281 Land Use Panel Members

#	Panel Member Name	Title	Agency
1	Buck Ford, Ph.D.	Superintendent	Blanco ISD
2	Kari Hutchison	Asst. Superintendent	Comal ISD
3	Rebecca Paskos	Senior Planner	City of San Antonio
4	Tyler Sorrells	Planner	City of San Antonio
5	Tom Hornseth, P.E.	County Engineer	Comal County
6	Stephanie Velasquez	Regional Transportation Planner	San Antonio-Bexar County MPO
7	Lydia Kelly	Bicycle & Pedestrian Transportation Planner	San Antonio-Bexar County MPO
8	Lance Freeman	Planner	San Antonio Water System
9	Gene Dawson, P.E.	President	Pape-Dawson Engineers
10	Susan Hughes	Board of Directors	Edwards Aquifer Authority
11	Jon Thompson	Associate Professor of Architecture	University of Texas—San Antonio
12	Tommy Hill, P.E.	Chief Engineer	Guadalupe-Blanco River Authority
13	Jim Cannizzo	Attorney	US Army—Camp Bullis/Ft. Sam Houston
14	Curtis Bremer	Appraiser	Retired
15	Dick McNary	Senior Vice President/COO	Project Control
16	David Kruse	Regional Data Center Director	Alamo Area Council of Governments
17	Derry Gardner	Appraiser	Gardner Appraisal Group, Inc.
18	Susan Wright	Community Liaison	Cibolo Canyon

Source: US 281 EIS Team, 2010.

The Land Use Panel participants attended two workshops and participated in a final round of communication with the US 281 EIS Team to complete the process. The first workshop took place on June 23, 2010, and focused on refinement of the proposed AOI boundary, identification of the most important factors influencing development, and delineation of indirect and cumulative impact area boundaries. The second workshop, held on July 21, 2010, aimed to gather participants' opinions on how the extent of future development might differ among the project's two primary design alternatives, with refinements addressing non-tolled, tolled, and managed options. Mitigation opportunities were also discussed to identify currently available and possible future resource protection/land use management tools to address impacts associated with the proposed improvements.

Workshop No. 1

Factors Influencing Development

The panel discussed factors likely to have the greatest influence on land development. The results were summarized by the US 281 EIS team and presented to the panel for approval at the second workshop. The most important development factors in the judgment of the panel are shown in **Table 4-12**.

Table 4-12: Factors Influencing Land Development in the US 281 AOI

Rank	Most Influential Factors in Land Development:	Subcomponents of Influential Factors:
1	Infrastructure	water/wastewater sewer road
2	Cost Considerations	land value economic conditions marketability market demand commute
3	Quality of Life	school district quality proximity to amenities aesthetic quality mobility crime/security/reputation

Source: US 281 EIS Land Use Panel, 2010.

Comments on Area of Influence (AOI)

Panel participants were briefed on the purpose and methods used to develop the AOI (see **Section 4.1.2 Study Area Boundaries: Area of Influence (AOI)**) and asked to comment and suggest modifications. Many panel members thought the initial AOI was too large and questioned the exclusion (at that time) of Camp Bullis. These suggestions were reflected in the AOI revisions presented at the second workshop.

Initial Predictions of Induced Development

Panel members worked in small groups with maps of the AOI showing: (1) existing development; (2) parcels that have received local government approval to develop, including approved subdivisions and master development plans; and (3) development-constrained areas, like parks or floodplains. The panel members were asked to focus on the remaining areas of currently undeveloped and uncommitted land within the AOI and to map the areas that are likely to be subject to development by 2035, assuming all currently known and reasonably foreseeable future infrastructural and other developments are implemented. The panel was then asked to repeat the exercise, this time assuming that all future developments will be built except the proposed improvements to US 281. The approved US 281 Super Street project was considered to be part of the existing, or No-Build, condition. The difference in area between the with- and without-project maps is considered to be the area of induced development associated with the proposed US 281 improvements. The small group working maps were compiled and analyzed by the US 281 EIS team and a draft induced development map was prepared for the panel's review at the second workshop.

Workshop No. 2

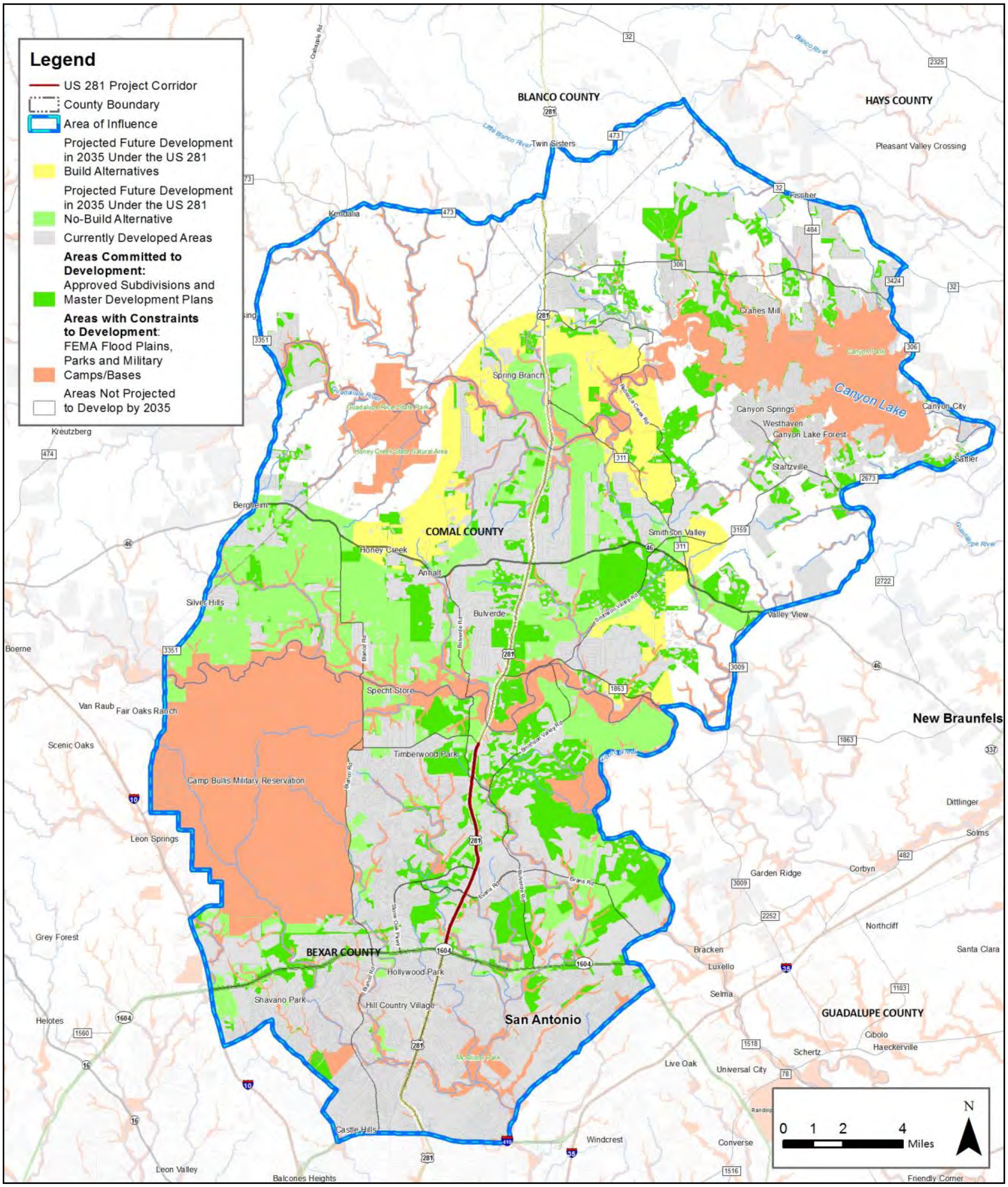
Review of Workshop 1 Results

Modifications to the AOI based on information gathered during Workshop 1 were presented to the panel during Workshop 2. Most panel members felt the revised boundary better reflected the extent to which the project might affect the surrounding area, while one panel member felt dividing Canyon Lake (in the northeast portion of the AOI) was an arbitrary cutoff. The AOI has since been revised again in response to panel comments and agency guidance (see **Section 4.1.2 Study Area Boundaries: Area of Influence (AOI)**). The land use panel was also shown the EIS Team's induced development interpretive map which was developed by the EIS Team based on the maps of predicted induced development drafted by the panel in Workshop 1. The interpretive map was used as a basis for refinement of development predictions expressed by the panel at Workshop 2. Overall, participants agreed with the representation of information collected from the first workshop, with some minor changes recommended that were taken into consideration in producing the final version of the induced development map.

Results of Induced Development Analysis

The results of the US 281 collaborative judgment analysis are shown in **Figure 4-6**. Overall, the panel predicted an area totaling approximately 37,000 acres of currently undeveloped and uncommitted land within the AOI as likely to be subject to development by 2035 under the US 281 No-Build Scenario. This area is shown in light green on **Figure 4-6**. The panel further predicted an additional area initially estimated at about 17,000 acres that would be subject to development by 2035 if US 281 Corridor Project was constructed. This area is shown in yellow on **Figure 4-6**. The approximately 17,000-acre induced development area is concentrated in the northern half of the AOI, extending from the Honey Creek area in the west, north to the intersection of US 281 and Rebecca Creek Road, and around the Smithson Valley area in the east. The area predicted by the US 281 EIS land use panel to be subject to induced land development is confined to Comal County and does not extend into Bexar, Kendall, or Blanco County.

Figure 4-6: Current and potential (2035) land development within the AOI with input from the land use panel, workshop #2



Source: US 281 EIS Team, 2010

Design Refinement based on Assessment of Build Alternatives

Updates were made to the Build Alternatives during the time between Workshop 1 and Workshop 2. Panel members were informed of these updates and asked to assess potential changes in the extent of induced land development based on the design refinements as well as the non-tolled/tolled/managed options:

1. Expressway Alternative (non-tolled, tolled, and managed lanes)
2. Elevated Expressway Alternative (non-tolled, tolled and managed lanes)

The panel was asked to predict whether the area they had identified as subject to induced development (the yellow area) would become larger or smaller depending on which of the Build Alternatives were to be constructed. The results from this exercise are shown in **Table 4-13** below.

Table 4-13: Influence of Alternatives on Induced Land Development (Shown as Average Percent Change in Extent of Mapped Area)

Build Alternative	Would expand (+) or contract (-) Induced Development Area by:*
Preferred Expressway Alternative	+10 %
Elevated Expressway Alternative	+12 %

Source: US 281 EIS Land Use Panel, 2010.
*rounded to the nearest whole percent

As an additional refinement, the panel was asked how the various toll options (non-tolled, tolled, and managed lanes) would further modify the areas subject to induced growth identified for each of the alternatives. Most of the participants indicated "not much change" or "no change." Some panel members thought that the tolled or managed lane options would result in reductions in the number of potential commuters, and therefore a reduction in the estimated extent of induced development, by as much as three percent for tolled and one percent for managed lanes (**Table 4-14**).

Table 4-14: Effect of Various Toll Options on Induced Land Development

Option	Build Alternative	
	Preferred Expressway Alternative	Elevated Expressway Alternative
Non-toll	(Non-toll condition considered baseline, so no change)*	(Non-toll condition considered baseline, so no change)*
Toll	-3%	-3%
Managed Lanes (Preferred)	-1%	-1%

Source: US 281 EIS Land Use Panel, 2010.
*rounded to the nearest whole percent

Summary of Collaborative Judgment Induced Development Analysis

Recognizing the lack of precision inherent in the overall predictive process, these plus-or-minus percentages were applied to the generalized prediction of induced growth to arrive at a comparative approximation, in acres, of the induced growth effects of the various design and tolling options (**Table 4-15**). The Elevated Expressway Alternative

(Non-toll) was estimated by the panel to have the largest effect, at approximately five percent of the AOI, or approximately 19,100 acres.

Table 4-15: Summary: Estimated Induced Development by Build Alternative

Toll Option	Build Alternative	
	Preferred Expressway Alternative	Elevated Expressway Alternative
Non-toll	18,700	19,100
Toll	18,100	18,400
Managed Lanes (Preferred)	18,500	18,800

Source: US 281 EIS Land Use Panel, 2010.
*rounded to the nearest hundred acres

4.6.3 Effects Related to Induced Growth

The preceding section discusses the degree to which the proposed US 281 Corridor Project would be likely to spur development within the AOI and concludes that implementation of any of the Build Alternatives would lead to growth that may have effects upon the human and natural environment. The importance of these indirect effects are discussed in this section and are further evaluated in **Chapter 5 - Cumulative Effects**, which considers the potential cumulative impacts to resources from past, present, and reasonably foreseeable future development, including those associated with the US 281 Corridor Project.

Indirect effects, and in particular induced development that may cause effects to sensitive environmental resources, are quantified where possible. These quantifications are approximate and should be considered on a resource by resource basis, keeping in mind the limitations associated with the probabilistic nature of some of the predictive methods used in this analysis. The following clarifications regarding quantitative information should be kept in mind:

- The area designated as the "induced development area" is not equivalent to a quantified extent or acreage of projected impacts. It does not depict the footprint of future development, but rather it is an area identified by the expert Land Use Panel within which land development is projected to occur. Actual future development impacts to land, water, habitat, and community resources are subject to further assumptions regarding the type of impact, the density, the design and mitigating elements of future land development scenarios, and the location of land development activities in relation to sensitive resource elements such as waterbodies, aquifer recharge features, and suitable habitat for sensitive species.
- Predicting future development and growth 25 years into the future entails an undefined amount of uncertainty. Collaborative judgment by land development experts is among the most reliable techniques available for forecasting indirect land use effects (Avin et al. 2007). Still, transformation of the experts' estimates of likely development areas from the collaborative map-based exercises into quantified development acreage, and then to impacts on resources, necessarily involves a series of assumptions that further limits the degree of certainty associated with cause-effect relationships.

- In some cases, characterizations of resource conditions that may be subject to induced development-related impacts are themselves the products of probabilistic analysis. For example, high quality GCWA habitat and high sensitivity archeology zones are estimated by modeling techniques which have ranges of accuracy. Likewise, characterizing the amount of aquifer recharge that would occur as direct loss from stream channels carrying storm water runoff from developed areas is based on a series of assumptions and recognized uncertainties that are inherent in recharge modeling techniques and/or the results of empirical sampling.
- Where estimates of land use change based on collaborative judgment are applied to probability-based estimates of resource conditions, like threatened and endangered species habitat, the level of uncertainty may be compounded. For this reason, quantifications of potential indirect effects, while useful for comparative purposes, should be viewed as broad estimates only.

Community Resources Effects

Five of the towns or populated places identified within the AOI in **Section 4.3.2 Socioeconomic and Community Resources**, including Anhalt, Honey Creek, Rebecca Creek Road, Smithson Valley, and Spring Branch, are in or near the area identified as the induced development area. These communities were visited in the spring and again in the fall of 2010. Potential changes to community cohesion and quality of life that could result from future development associated with the proposed US 281 improvements are described in general terms in **Section 4.3.2 Socioeconomic and Community Resources** and addressed in this section.

Anhalt Hall- SH 46 and Anhalt Road

Anhalt

Anhalt is a populated place located north of SH 46 and west of Bulverde in western Comal County. What was then known as Krause Settlement was established in 1859 by German pioneers, who banded together in the early years for protection against Indians. In 1876 they formed an organization called Germania Farmers Verein, which later expanded into mutual insurance and social activities. In 1887 the Verein built a meeting hall, which they enlarged in 1896. Today, hundreds of people still gather at Anhalt Hall for Mayfest, Summerfest and Oktoberfest organized by the German Farmers Association. Local farmers and area residents come together to exhibit field and garden products, livestock, and hold a barbeque cook off. The hall is also used for weddings, musical events, and other public and private gatherings (Haas 2011a).

Although the original settlement area is scarcely populated, with a few scattered houses and ranches, Anhalt Hall remains an element of shared historical and social identity among descendants of the early settlers. Other tangible signs of community cohesion, such as the Anhalt post office which closed in 1907, have been lost or absorbed into the growing suburban community of Bulverde.

Honey Creek

Honey Creek, in far western Comal County, is listed as a populated place on the USGS Bergheim quad along SH 46 partially within the incorporated boundary of Bulverde. The original settlement, part of the mass migration of Catholic German immigrant families in the late 1840s initiated by Prince Carl of Solms-Braunfels, was located further north near the confluence of Honey Creek and the Guadalupe River. Honey Creek was named for the large numbers of honeybees near the creek and an abundance of an unusual limestone rock formation locally known as "honeycomb rock. The original 1876 settlement church, named St. Joseph's Catholic Church, has been relocated and rebuilt numerous times. The original church was located near the Honey Creek Cemetery off State Park Road 31. In 1892, the church was moved to its present site along SH 46 between Blanco Road and Bulverde Road. Today St. Joseph's Catholic Church is a visually imposing stone structure serving around 300 families in the area. It remains as an element of community cohesion and historical identity that can be traced to the earliest days of settlement. The building that now houses the Honey Creek Restaurant once served as a grocery store, feed and seed store, and restaurant serving the residents of Honey Creek and Anhalt. Due to economic growth in the area it remains a popular destination known for its barbeque and catfish. Residential land uses in the area consist of homes of varying age and architectural styles dispersed on ridgetops along Willow Springs, Laswell, and Berry Roads south of SH 46. Most other community elements associated with Honey Creek have been lost or absorbed into the communities of Bulverde and Spring Branch (St. Joseph Catholic Church-Honey Creek 2011; Gass 2011).

Honey Creek Restaurant, at SH 46 and Oak Cliff Dr., once served as a grocery store, feed and seed store, and restaurant serving the residents of Honey Creek and Anhalt

Rebecca Creek Road Neighborhood

Another area of anticipated induced development occurs along Rebecca Creek Road which intersects US 281 north of Spring Branch and winds in a southeasterly direction across the Guadalupe River to its junction with FM 311 near Smithson Valley. The road runs along Rebecca Creek, which rises in southeastern Blanco County and runs southeast for about eight miles to its mouth on the western edge of Canyon Lake on the Guadalupe River. Several springs and ponds, mostly dammed up, lie along the creek, which crosses an area of steep slopes and limestone benches characteristic of the Balcones Escarpment, giving a stair step look to the landscape along the creek. Although not associated with historic settlements in the area, the landscape views and environmental aesthetic quality of this corridor have encouraged more recent residential development in areas of "The Road" both north and south of the Guadalupe River crossing, establishing a community identity among residents. The area south of the Guadalupe River has established a self-identified neighborhood that includes the Mountain Springs Ranch, Rebecca Creek Ranches, Cordova Bend, and other subdivisions. Future development in this area would have to contend with the flood prone nature of the crossings of the Guadalupe River and its tributaries. The two-lane roadway (with a one-lane low water crossing at one point) will limit mobility for a substantially increased population along the corridor, although the Comal County Major Thoroughfare Plan proposes to upgrade Rebecca Creek Road to a collector road with an 80 foot ROW (Haberkorn 2011; Haas 2011d; Comal County Engineers Office 2010).

Smithson Valley

Smithson Valley is a populated place located in the vicinity of the intersections of SH 46, FM 311, and FM 3159 in central Comal County. The community was named for Ben Smithson, who settled in the area in 1856. By the turn of the century, the town had developed as a supply and social center for local farmers and cedar choppers. The town began to decline during the last century; the post office closed, the Smithson Valley school was consolidated with others, and the population of the town was typically estimated at between fifteen and twenty, even as late as 2000. However, that figure failed to capture the rapid growth that began in the early 1990s in central Comal County, a formerly rural area centered on Smithson Valley. Numerous housing and commercial projects were developed to serve an influx of residents from the San Antonio area. Smithson Valley High School, part of Comal County Independent School District, is a good reflection of this growth. The facility opened in 1976, with an initial graduating class of 71. In 1988, a new campus was opened on FM 311 at a site described by Texas Highways magazine as "one of the most beautiful campus sites in the state, with its gorgeous views of the hills and valleys". Today, the Smithson Valley campus serves an area of over 300 square miles including Canyon Lake, Bulverde, Spring Branch southern Blanco, Fischer, and parts of Boerne and northern San Antonio. The 5A school currently has an enrollment of over 2,500 students. Smithson Valley is also the site of one of the few employment centers to develop within the AOI north of San Antonio. GVTC is a telecommunications company offering cable, internet and phone services to 11 counties throughout the Hill Country. GVTC employs 162 people who live in Smithson Valley or the surrounding communities (Comal ISD 2010; Haas 2011e).

GVTC, located in Smithson Valley at FM 3159 and SH 46

Spring Branch

Spring Branch is an unincorporated community located east and west of US 281 near its intersections with FM 311 and Spring Branch Road in western Comal County. Although historically distinct, the areas of Spring Branch and Bulverde are often considered together as a suburban extension of the San Antonio metropolitan area. For example, a single entity represents both communities as the Bulverde/Spring Branch Chamber of Commerce. Spring Branch was originally settled by the Knibbe family in 1852; and derives its name from a spring-fed creek that flows into the Guadalupe River. The small community had its own post office from 1858 until about 1986. After the completion of Canyon Dam in the mid-1960s, residential growth and subdivision development expanded the population considerably. As indicated on **Figure 4-6**, the area immediately surrounding the original Spring Branch community is expected to grow by 2035 regardless of the proposed US 281 improvements. However, this future development zone is likely to expand both east and west if the US 281 improvements are implemented. Cohesive elements of the Spring Branch community, like the Spring Branch School, post office, and Community Center, are located near the highway intersection and have been responding to growth for many years. Other facilities are also important to Spring Branch residents, like the Spring Branch Store, the local feed and seed store, and the volunteer fire department (Haas 2011f; Bulverde/Spring Branch Area Chamber of Commerce 2009).

Spring Branch Community Center- FM 311 and US 281 N.

Summary of Induced Growth Effects on Communities

The nineteenth century farming communities settled by German immigrants in the southern Hill Country have been undergoing a process of change for several decades. Some of these communities within the AOI retain elements of spatial and social cohesion that would be vulnerable to rapid and incompatible development. Some, like Kendalia or Fischer, lie near the margins of the AOI beyond the predicted area of foreseeable development in 2035. Other AOI communities, like Bulverde, have been experiencing development pressure for many years and have been relatively successful in retaining important elements of physical and social cohesion through land use planning and management, as evidenced in the City's Comprehensive Plan, described in **Section 4.2 Step 2: Identify the Study Area's Goals and Trends** above. The communities or populated places that are located within the induced development area may retain some notable elements that help preserve a sense of shared economic and social identity in the way the Verein Hall links Anhalt area residents to nineteenth-century farming traditions. However, other elements of cohesion in the populated places that are subject to induced development—Anhalt, Honey Creek, Smithson Valley, Spring Branch, Rebecca Creek Road—have, to a great extent, been absorbed by the low density development of the last several years. The effects of induced development associated with the proposed US 281 improvements on the cohesion of these communities or populated places, is not expected to be substantial in light of the transition currently affecting the area.

Ecological Resources Effects

Federally-Listed or Potentially-Listed Threatened and Endangered Species

Mussels

The mussel species known to historically occur in the AOI are primarily known from perennial streams and rivers; particularly the Guadalupe and, to a lesser degree, the San Antonio River. Freshwater mussels filter algae and small particles from water and most species have a larval stage that is parasitic to fish. The larvae (glochidia) are released by the female mussel and must quickly locate a certain host fish species or die. They typically attach to the host fish's gills or fins and remain for a few weeks or months. This relationship is rarely harmful to the host fish under natural conditions (TPWD 2010i).

Given the uncertainty about these species' actual ranges and population densities, specific quantified impacts to mussel habitat in the AOI are not available; however, water quality impacts and increased flooding associated with induced development would be the primary concern with this suite of species. The TPWD (2010i) Mussel Watch Program cites the following primary threats to freshwater mussels:

- Changes in flow rates of rivers and streams due to droughts, floods, or building of dams;
- Increased deposition of soft silt due to excessive run-off;
- Scouring of stream beds during storm events;
- Increased amounts of aquatic vegetation;
- Lack of suitable native fish hosts for larval stage;
- Aquatic contaminants;
- Introduction of exotic species.

Various regulatory and conservation programs associated with surface water quality and floodplain protection are in place which likely would prevent or lessen these potential impacts. Specific protections and increased monitoring and research are expected to result from the relatively recent TPWD and potential USFWS listings for these species.

Terrestrial Karst Invertebrates

At this time no karst invertebrate critical habitat is designated outside of Bexar County in the AOI. Therefore, the bulk of the following discussion pertains to potential encroachment-alteration effects within Bexar County; however, the listed species could occur within karst features currently not known to harbor them in induced development areas in the AOI. It is possible that rare or as-yet undescribed species, while currently un-listed by TPWD or USFWS as threatened or endangered, could be identified in the induced development area in the AOI that could become listing candidates. Effects related to induced development to currently-listed or potentially future-listed terrestrial karst species cannot be reliably quantified.

Golden-cheeked Warbler – Recovery and Viability Context

The current *Golden-cheeked Warbler (GCWA) Recovery Plan* (USFWS 1992) identifies criteria to be met for the warbler to potentially be down-listed from endangered to threatened. Overall, these recovery criteria require the protection of sufficient breeding habitat to ensure the continued existence of at least one viable, self-sustaining warbler population in each of the eight recovery regions delineated in the recovery plan; where the potential for gene flow exists across regions to ensure long-term viability of the protected populations. The US 281 AOI falls within GCWA recovery Region 6 (see **Section 4.2 Step 2: Identify the Study Area's Goals and Trends** for a summary of the USFWS recovery plan). Other key recovery strategies for the GCWA include the identification and protection of "focal areas" that include a single, viable warbler population or one or more smaller populations that are interconnected; and protecting and managing abundant and scattered patches of habitat outside of the focal protection areas (USFWS 1992).

In 1995, the USFWS sponsored a "Population and Habitat Viability Workshop" in Austin, Texas. One recommendation issuing from this workshop was to protect sufficient habitat for a carrying capacity of 3,000 breeding pairs for each GCWA recovery region. In addition, habitat measures within the regions were recommended and include prevention of habitat damage by herbivores, habitat restoration, maintenance of high percent canopy cover of trees, oak wilt prevention, predator and nest parasite control, limiting human impacts in habitat, and implementing landscape level planning (USFWS 1996a).

In their draft Resource Assessment for the GCWA for the Southern Edwards Plateau Habitat Conservation Plan (SEP-HCP) Plan Area (Loomis Partners 2010), the authors state that conservation actions in the Plan Area that would be consistent with achieving recovery of the species in USFWS Recovery Region 6 might require the permanent protection and management of approximately 75,000 acres of relatively high quality GCWA habitat. This broad estimate is based on achieving a protected population of 3,000 pairs at an average density of approximately four pairs per 100 acres which is the long term average density of the species recorded on Camp Bullis (Loomis Partners 2010).

Golden-cheeked Warbler – US 281 Indirect Effects

Given the uncertainties inherent in predictive methodologies, precise indirect impacts to the GCWA caused by the US 281 project cannot be reliably quantified. However, as discussed in **Section 4.6.2 Induced Growth Effects**, the panel of land use and development experts in the region who contributed to the project estimated that potential US 281-induced land development areas could range from approximately 18,100 to 19,000 acres, depending on the Build Alternative. There would be minor encroachment–alteration effects on potential habitat along the proposed project corridor, but the focus is clearly upon induced development effects to this species.

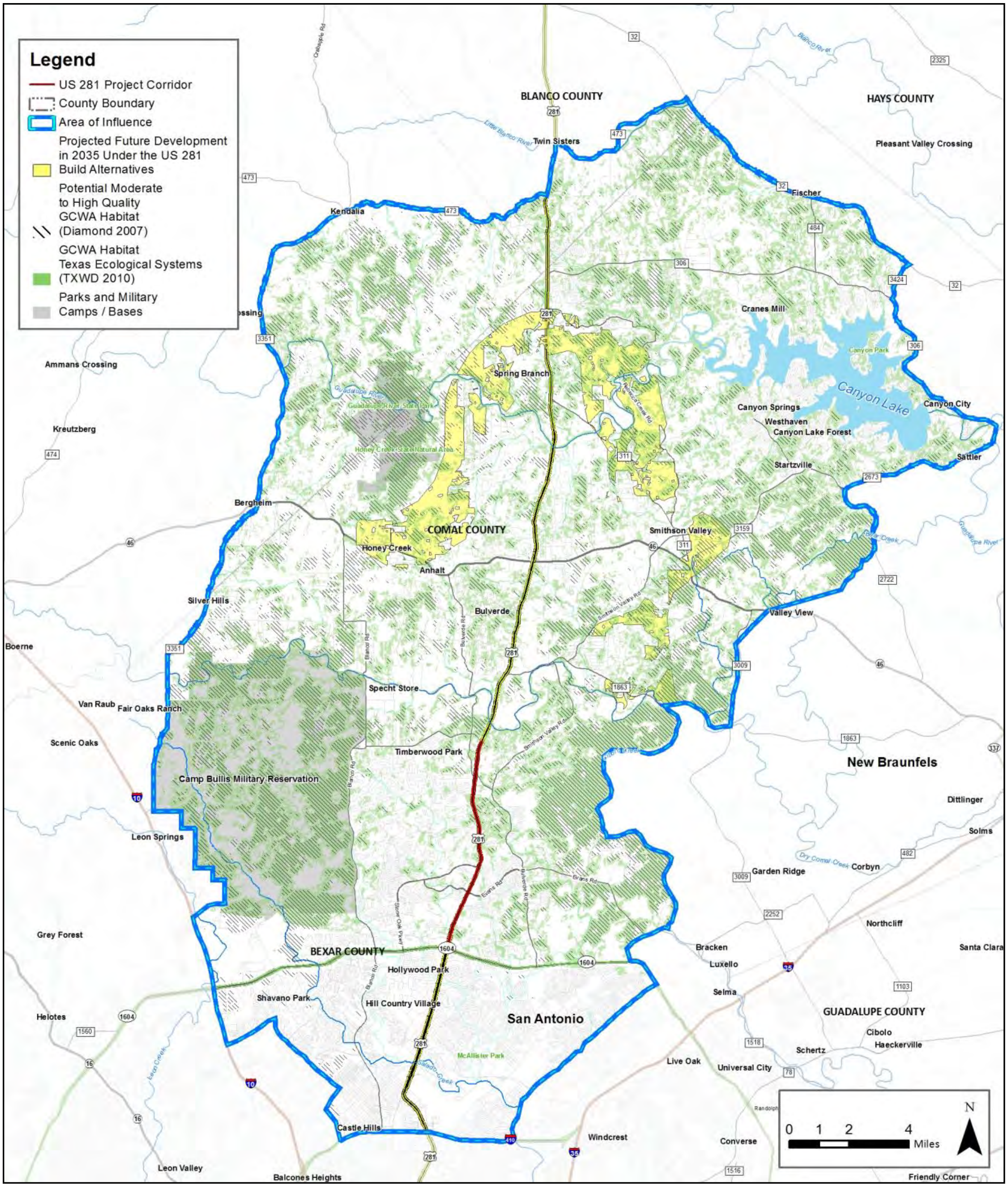
In an attempt to quantify potential impacts to the GCWA, two primary habitat models were selected: the Diamond Model C (Diamond 2007) and TPWD Ecological Mapping Systems of Texas (EMST) vegetation mapping for selected vegetation classes representing primarily oak – Ashe juniper woodland vegetation (TPWD 2010h). An explanation of the EMST vegetation classes selected to represent potential GCWA habitat for this analysis is presented in **Section 5.6.4 Cumulative Effects of Ecological Resources** of the cumulative effects chapter. The selection of these models is based largely upon availability during the period of analysis. There are other models that were not selected due to proprietary limitations (e.g., Loomis Austin 2008 and SWCA 2007) or because they have not yet been released to the public domain (Models I, II & III – Morrison et al. 2010).

Even within existing models, there are many versions depending upon adjustments for various landscape and vegetation factors. After conversations with Dr. Diamond, it appeared that version C was a good middle-of-the-road choice for analysis within the AOI (Diamond 2010). For the purpose of the general impacts discussion in this document, habitat quality Rank 4 was chosen as a proxy for moderate to high quality GCWA habitat.

The selected TPWD EMST vegetation classes represent a proxy of potential GCWA habitat that provides an estimate of an extent of potential habitat that is substantially greater than the Diamond C model potential habitat area. The Diamond C model provides a more conservative estimate because of its focus on specific GCWA habitat features that include but are not limited to vegetation types.

Figure 4-7 shows the location of potential GCWA habitat in the AOI, represented by: (1) the Diamond Model C; and (2) selected TPWD EMST vegetation classes, in relation to the areas subject to projected induced development in 2035 as estimated by the US 281 EIS Land Use Panel. **Table 4-16** quantifies total acres of potential moderate to high quality habitat in the AOI and areas of the same within the areas subject to US 281-induced development within the AOI. As previously discussed, the yellow zone on **Figure 4-7** represents the area identified by the US 281 EIS Land Use Panel within which future (2035) land development is likely to occur if the proposed improvements to US 281 are implemented. For **Figure 4-7**, the other current and projected future land development zones and most of the development-constrained areas shown on **Figure 4-6** were removed in order to focus on the projected induced development areas in relation to potential GCWA habitat. As can be seen on **Figure 4-6**, there are substantial areas of land with constraints to development, as well as areas conducive to development, that are not anticipated to develop within the 2035 timeframe. This overall context of developed and undeveloped zones in relation to potential GCWA habitat will be discussed in **Chapter 5 - Cumulative Effects**.

Figure 4-7: Potential GCWA habitat in relation to areas subject to induced development



Source: US 281 EIS Team, 2010

Table 4-16: Potential GCWA Habitat within the AOI and within Projected Induced Development Areas under the US 281 Build Alternatives

Potential GCWA Habitat	Total AOI Areas of Potential Habitat	Preferred Expressway Alternative (as % of Potential Habitat in AOI)	Elevated Expressway Alternative (as % of Potential Habitat in AOI)
Diamond Model C: Habitat Quality 4*	68,119	5,057 (7%)	5,263 (8%)
TPWD Live Oak-Ashe Juniper Woods	119,094	7,417 (6%)	7,668 (6%)

Source: Diamond 2007; TPWD 2010
*Defined as potential moderate to high quality habitat

Potential GCWA habitat totals within the area subject to induced development range from 5,057 acres to 7,668 depending on the Build Alternative and the data used. To the extent that some portions of the above-referenced amounts of potential habitat might be occupied by the GCWA, this represents a substantial impact from projected induced development. Six to eight percent of the potential GCWA habitat in the AOI could potentially be impacted. Comparison of the alternatives in **Table 4-16** indicates that the Preferred Expressway Alternative could affect lower amounts of potential GCWA habitat than the Elevated Expressway Alternative, which could potentially impact the largest amount. The Diamond Model C and the EMST vegetation classes provide conjectural information and most likely overestimate potential habitat and, more certainly, occupied habitat.

Nevertheless, **Figure 4-7** draws attention to some particular locations of remaining high quality habitat in the AOI and the potential for those areas to be affected by US 281 Corridor Project-induced development.

Black-capped Vireo – Recovery and Viability Context

The AOI is within the USFWS BCVI Recovery Region 3 – Southeast Edwards Plateau Recovery Region (USFWS 1991). There has been a recommendation by the BCVI Population and Habitat Viability Assessment Report (USFWS 1996b) to redraw the recovery region which would place the AOI in proposed Recovery Region 2 – Edwards Plateau Recovery Region. The USFWS completed a recent status review of the BCVI which assessed the current status of the species in the context of these revised recovery region boundaries, and recommended that the species be down-listed to threatened status (USFWS 2007).

The down-listing recommendation comes largely from new locality data acquired since the BCVI listing which indicates their total known population in Texas is much larger than previously known. This is possibly due to an increase both in the overall population size and/or increased survey efforts identifying populations at new locations. Although the tendency might be to downplay the risks to a larger population base, the status review indicates that threats to this species remain and recovery still depends on successful implementation of threat-reducing management actions (USFWS 2007).

Primarily due to the reasons stated above, the 1991 BCVI Recovery Plan is generally regarded as out-of-date; however, the recovery criteria listed in the 1991 Recovery Plan call for the protection of at least one viable vireo population composed of at least 500 to 1,000 breeding pairs in each of six recovery regions in Texas, Oklahoma, and Mexico (USFWS 2007).

The closest BCVI population estimate in the vicinity of the US 281 project area comes from Loomis (2010) in the draft Resource Assessment for the BCVI for the SEP-HCP Area (Bexar, Medina, Bandera, Kerr, Kendall, Blanco, and Comal counties). The authors state that many of the known BCVI populations in the Plan Area occurred on currently protected properties, and the size of the currently known protected population is approximately 420 breeding units (Wilkins et al. 2006).

Black-capped Vireo – US 281 Indirect Effects

For a variety of reasons, BCVI habitat is virtually impossible to detect using remote sensing methods and no reliable models are available for large scale habitat quantification. This is due to the scrubby, successional and often disturbance-related nature of BCVI habitat in the southeastern Edwards Plateau Ecoregion. Given the inability to quantify potential habitat impacts to this species, it is even more difficult to quantify indirect effects resulting from induced development. The general raw ingredients are present for BCVI habitat in the AOI and it is reasonable to assume some habitat would be displaced by induced development.

Aquifer and Spring Dependent Species

Seven federally endangered and one threatened species are dependent on the San Marcos and Comal Springs ecosystems. These include two salamanders, the Texas blind salamander and San Marcos salamander; two fishes, the fountain darter and San Marcos gambusia; two aquatic insects, the Comal Springs riffle beetle and Comal Springs dryopid beetle; one crustacean, Peck's Cave amphipod; and one plant, Texas wild-rice.

These species are not present in either the project corridor or the area of projected induced development within the AOI. Therefore, no direct or encroachment-alteration indirect effects on them are anticipated. There are, however, three species of salamander (*Eurycea tridentifera, E. neotenes, E. latitans*) that the USFWS has determined may warrant listing, two of which are currently state-threatened, and the known distributions of these species intersect a portion of the AOI in Bexar and Comal counties. No salamanders were encountered during any of the biological investigations in the project area. It is possible that groundwater quality effects related to induced development over the recharge zone could have some level of impact on known Comal and/or San Marcos Springs species. However, given the distance of the US 281 Corridor Project from Comal Springs (approximately 20 miles) and the TSS removal which would be achieved with TCEQ-approved storm water BMPs, indirect effects resulting from the US 281 Corridor Project to Comal Springs are not reasonably certain to occur in the future.

State-listed Species and Other Wildlife Effects

Cagle's Map Turtle

On April 8, 1991, Cagle's map turtle was petitioned to be listed as a federally endangered species (Killebrew 1991) and designated as a candidate species on January 22, 1993. The USFWS indicated that listing of the species was warranted, but precluded at that time because the agency lacked the resources to propose the species for listing (58 FR 5701). Several years later, the TPWD listed Cagle's map turtle as a state-threatened species on November 16, 2000 (Texas Register, Title 31, Chapter 65). After reviewing the turtle's status, the USFWS announced on September 12, 2006, that, because of stable population size, increased protection, and no foreseeable threats from reservoir construction, the listing of Cagle's map turtle was no longer warranted (71 FR 53767).

The Cagle's map turtle formerly ranged throughout the watersheds of the Guadalupe and San Antonio Rivers (Dixon 1987, Conant and Collins 1991), but may now be extirpated in the San Antonio basin (Vermersch 1992). This turtle tends to inhabit limestone or mud-bottomed streams with moderate current and pools of varying depths. It may also be found in slow-moving water behind impoundments (Vermersch 1992).

Cagle's map turtle is primarily threatened by loss and degradation of riverine habitat resulting from construction of dams and reservoirs and, secondarily, to over-collecting for the pet trade, zoos, museums, and scientific research (Killebrew 1991). The limited distribution of this turtle makes the species inherently more vulnerable to extinction than other wider-ranging species. Alteration of a single river system can impact suitability of potential nesting habitat and, in turn, negatively affect hatch rates and sex ratios (Wibbels et al. 1991). A relatively minor portion of the Cagle's map turtle population occurs in the area affected by induced growth, reported by Killebrew et al. (2002) to be roughly 11 percent of the population in the upper Guadalupe River. No probable substantial impacts to the state-listed Cagle's map turtle are expected as a result of the US 281 Corridor Project-induced growth. There is a low potential for indirect impacts to this species in the upper Guadalupe River drainage area.

Texas Horned Lizard

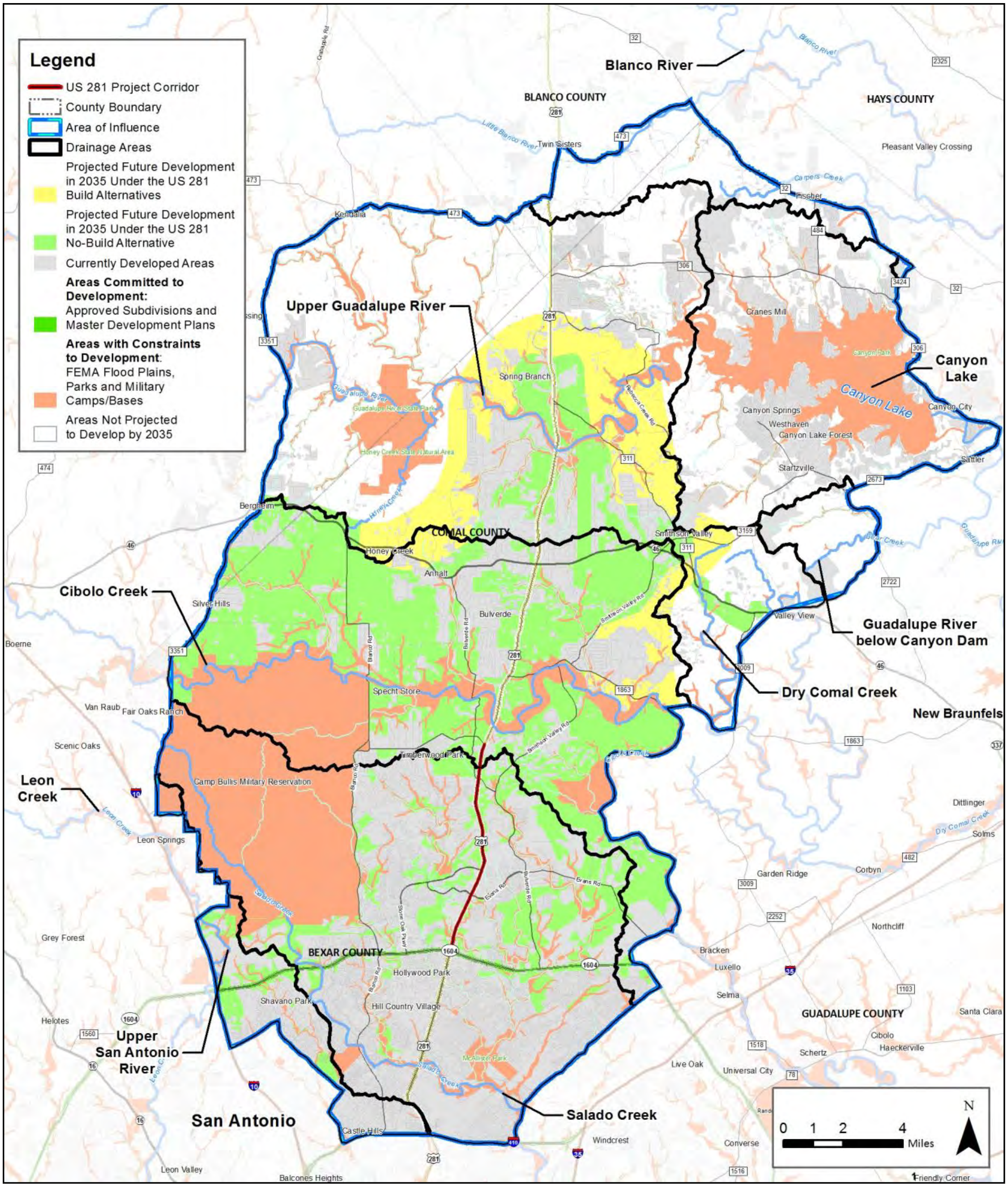
Very little research has been done on Texas horned lizard (THL) population dynamics, aside from the TPWD's Texas Horned Lizard Watch which utilizes volunteer observers throughout the state who monitor their lands and report THL findings (Linam 2008). THLs are seldom found in the southeast portion of the Edwards Plateau Ecoregion today. Data from TPWD's *Texas Horned Lizard Watch 10-Year Summary Report* (1997-2006) indicates that the THL is seen in only 47 percent of evaluation sites in the Edwards Plateau. It tends to only occupy portions of the area underlain by sandy, clayey and loamy soils and is typically not found in rocky areas. The THL disappeared from the Edwards Plateau evaluation sites in Bexar and Kendall Counties during the ten-year period of study (it was present in 1997-99 but absent 2005-07). There are no data from Blanco and Comal Counties (Linam 2008). This species would be most vulnerable from induced development particularly in those portions of the induced development area supporting native range plants in deeper soils, which is likely a fairly small subset of the AOI. Quantitative habitat estimates are not available; however, some level of impact might occur to the species as a result of development induced by the project.

Water Resources Effects

Surface Water

The analysis of water quality effects related to induced development was conducted by stratifying the AOI by drainage areas for key waterbodies. These include: the upper Guadalupe River, Canyon Lake, Cibolo Creek, Dry Comal Creek, the Blanco River, Salado Creek and the upper San Antonio River. The area of projected induced development for the year 2035 was then overlain on the different drainage areas to ascertain which drainage areas could be affected by projected induced development, and the relative degree to which they are expected to be impacted. This analysis is illustrated graphically in **Figure 4-8**, which shows the key drainage areas in relation to the area of projected induced development in 2035 (in yellow). Also shown in **Figure 4-8** are other areas projected to develop by 2035 but not considered to be induced by the proposed US 281 improvements (shades of green), areas currently developed (grey), areas considered to be constrained from development (orange) and areas not projected to develop by 2035 (white). The influence of these other development factors on water quality will be considered in the cumulative effects analysis.

Figure 4-8: Drainage areas for major streams within the AOI



Source: US 281 EIS Team, 2010

In addition to considering the location and extent of projected induced development, the indirect water quality effects analysis also considers the types of potential development in these areas, and the intensity or density of potential development. The type of projected future development that is assumed for this water quality analysis may be described as suburban residential development that is primarily single-family homes with associated commercial development in the vicinity of road intersections. This is based on observations of recent development trends in the AOI, as discussed in **Section 4.2 Step 2: Identify the Study Area's Goals and Trends,** and on the analytical assumptions applied in the generation of population and housing projections for this study (SA Research Corporation 2010).

The density of future development in different drainage areas of the AOI was also inferred from the SA Research Corporation Study (SA Research Corporation 2010). The population and housing development projections were divided by Residential Housing Sectors that were designated to show the likely phasing of future development within the AOI. These projections are discussed further in **Section 5.5.2 2035 Development Estimate based on Population Projections and Residential Absorption Analysis**; the population growth by residential sectors is shown on **Figures 5-13** and **5-14**.

The location, extent, and density of suburban residential and commercial development are relevant to the question of potential water quality impacts because of the phenomena of storm water runoff and the changes in runoff quality and quantity that occur as land cover changes from natural vegetation, as well as rural agricultural rangeland uses to urban and suburban residential and commercial uses. Storm water runoff from developed areas, commonly referred to as urban runoff, has been documented as a source of a wide range of pollutants and associated pollutant loads that exceed background levels from undeveloped land, leading to water quality degradation in receiving waters. Pollutants commonly reported in characterizations of urban storm water include pathogen indicators such as bacteria, nutrients such as nitrogen and phosphorous, biological and chemical oxygen demand, heavy metals and toxic constituents including pesticides and hydrocarbons (EPA 1999; NCHRP 2006). The origin of these pollutants in urban runoff has been attributed to various sources with the developed areas, including rooftops, yards and other landscaped areas, malfunctioning on-site wastewater treatment (septic) systems, driveways, sidewalks, parking lots, and road systems.

Other common effects of urban and suburban development on water resources include alteration of stream temperature regimes (Schueler 2000a), and stream channel morphology changes, including channel erosion and destabilization, with associated adverse effects on aquatic life habitat. These latter types of effects occur as geomorphic responses to changes in the hydrologic regime and runoff characteristics (Leopold et al. 1964), including increases in peak storm flows and other changes in the timing and volume of watershed runoff, caused by increases in watershed imperviousness associated with development.

Many investigators studying the effects of urban runoff have concluded that the degree of impervious surfaces (also referred to as impervious cover) within a watershed is a meaningful and reasonable indicator of watershed stresses that lead to water quality impacts, including impacts to aquatic life communities and habitats and waterbody physical integrity (see, for example, studies reviewed in Schueler 2000a and Brabec et al. 2002). Because of the utility of using imperviousness as a measurable indicator, among other reasons, impervious cover limits have been incorporated into land development regulations in the City of San Antonio as a water pollution control measure for protection of the Edwards Aquifer and the streams by which it is recharged.

The impervious cover associated with urban and suburban development can be viewed as having two primary components: (1) rooftops of buildings, and (2) the transportation system that includes roads, driveways and parking lots. Schueler (2000a) reports that in suburban developments, the transportation system component generally makes the greatest contribution to imperviousness. According to Schueler (2000a), total impervious area associated with medium density single-family housing development can range from 20 percent to nearly 50 percent depending on the layout of streets and parking areas, which can vary widely. This illustrates that density controls themselves (i.e. housing units per acre) may not be sufficient for controlling imperviousness.

Multivariate bioassessment techniques for evaluation of aquatic macroinvertebrate and fish communities, as well as other components such as algal communities and habitat, have been shown to be effective approaches for characterizing the effects of non-point source pollution and watershed influences such as land development and urbanization (Karr and Chu 1999; Booth et al. 2001). One of the earliest and most widely cited studies to report on observed relationships between water quality indicators and indicators of urbanization, such as the degree of watershed imperviousness, was done by Klein (1979), who reported as a principal finding that stream quality impairment becomes evident at a watershed imperviousness of 12 percent. Numerous subsequent studies reported similar levels of watershed imperviousness as being associated with declining and/or degraded conditions based primarily on biological indicators of water quality and stream health. These studies were summarized by Schueler (2000a), and his summary is reproduced below in **Table 4-17**.

Table 4-17: Review of Key Findings of Urban Stream Studies Examining the Relationship of Urbanization to Stream Quality (from Schueler 2000a)

Ref.	Year	Location	Biological Parameter	Key Finding
Booth	1991	Seattle	Fish habitat/channel stability	Channel stability and fish habitat quality declined rapidly after 10 percent impervious
Galli	1994	Maryland	Brown Trout	Abundance and recruitment of brown trout declines sharply at 10-15 percent impervious
Benke *et al*	1981	Atlanta	Aquatic insets	Negative relationship between number of insect species and urbanization in 21 streams.
Jones and Clark	1987	Northern Virginia	Aquatic insects	Urban streams had sharply lower diversity of aquatic insects when human population density exceeded four persons/acre (estimated 15-25 percent impervious cover).
Limburg and Schmidt	1990	New York	Fish spawning	Resident and anadromous fish eggs and larvae declined sharply in 16 tributary streams greater than 10 percent impervious
Shaver *et al*	1994	Delaware	Aquatic insects	Insect diversity at 19 stream sites dropped sharply at 8 to 15 percent impervious
Shaver *et al*	1994	Delaware	Habitat quality	Strong relationship between insect diversity and habitat quality; majority of 53 urban steams had poor habitat.

Table 4-17: Review of Key Findings of Urban Stream Studies Examining the Relationship of Urbanization to Stream Quality (from Schueler 2000a)

Ref.	Year	Location	Biological Parameter	Key Finding
Schueler and Galli	1992	Maryland	Fish	Fish diversity declined sharply with increasing impervious, loss in diversity began at 10-12 percent impervious
Schueler and Galli	1992	Maryland	Aquatic insects	Insect diversity metrics in 24 subwatersheds shifted from good to poor over 15 percent impervious
Black and Veatch	1994	Maryland	Fish/insects	Fish, insect and habitat scores were all ranked as poor in five subwatersheds that were greater than 30 percent impervious
Klein	1979	Maryland	Aquatic insects/fish	Macroinvertebrate and fish diversity declines rapidly after 10 percent impervious
Luchetti and Fuersteburg	1993	Seattle	Fish	Marked shift from less tolerant coho salmon to more tolerant cutthroat trout populations noted at 10-15 percent impervious At 9 sites.
Steedman	1988	Ontario	Aquatic insects	Strong negative relationship between biotic integrity and increasing urban land use/riparian condition at 209 stream sites. Degradation begins at about 10 percent impervious
Pedersen and Perkins	1986	Seattle	Aquatic insects	Macroinvertebrate community shifted to species tolerant of unstable conditions.
Steward	1993	Seattle	Salmon	Marked reduction in coho salmon populations noted at 10-15 percent impervious at 9 sites.
Taylor	1993	Seattle	Wetlands plants/amphibians	Mean annual water fluctuation was inversely correlated to plant and amphibian density in urban wetlands. Sharp declines noted over 10 percent impervious
Garie and McIntosh	1986	New Jersey	Aquatic insects	Drop in insect taxa from 14 to 4 noted in urban streams.
Yoder	1991	Ohio	Aquatic insects/fish	100 percent of 40 urban sites sampled had fair to very poor index of biotic integrity scores.

Source: Schueler 2000a.

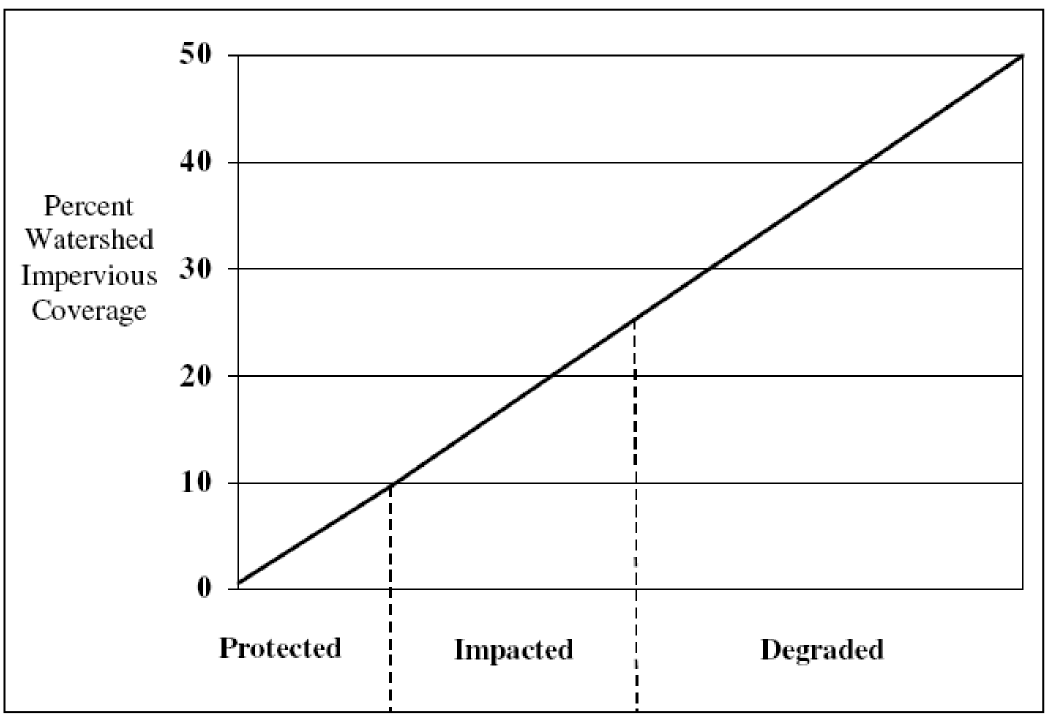
In summary, there is evidence that urban and suburban development with residential and commercial land uses, and the associated increases in watershed imperviousness, can lead to water quality and aquatic ecosystem degradation. Such degradation has been documented through numerous studies as becoming evident when watershed imperviousness reaches a level of between 10 and 15 percent, and the degradation may become irreversible at higher levels of development-related imperviousness. Wang et al. (2001) suggested a lower threshold range of 8 to 12 percent imperviousness as a level where minor changes in urbanization could result in major changes in stream condition. Other investigators evaluating the relationships between a variety of biological and water quality indicators and multiple watershed condition parameters have confirmed the usefulness of impervious cover as an overall index parameter, but caution that there is no clear threshold, but rather a continuum of increasing degradation with increasing watershed development (Booth et al. 2001; Karr and Chu 1999).

Deitz and Clausen (2008) summarized the state-of-the-knowledge in the following way:

> *"A degradation threshold value at about 10% imperviousness has been cited by several authors (Booth and Reinelt, 1993; Klein 1979; Schueler 1994, 2003; Wang et al. 2001). Watersheds with low levels of imperviousness may have a broad range of responses due to complex watershed interactions, but highly developed watersheds have uniformly poor conditions (Booth et al., 2004; Wang et al., 2001). Interpretation of threshold values in the literature should be done carefully due to the use of different measurement methods (Brabec et al. 2002). However, a definite relationship appears to exist between impervious area and multiple measures of stream health."*

Recognizing that many urbanizing areas will not be able to achieve the lower levels of imperviousness suggested by the research as being associated with high water quality and healthy aquatic ecosystems, Schueler (2000a) proposed a stream classification scheme that has been used and adapted by water quality and land use planners (Arnold and Gibbons 1996) to set achievable goals. This scheme is shown in **Figure 4-9**.

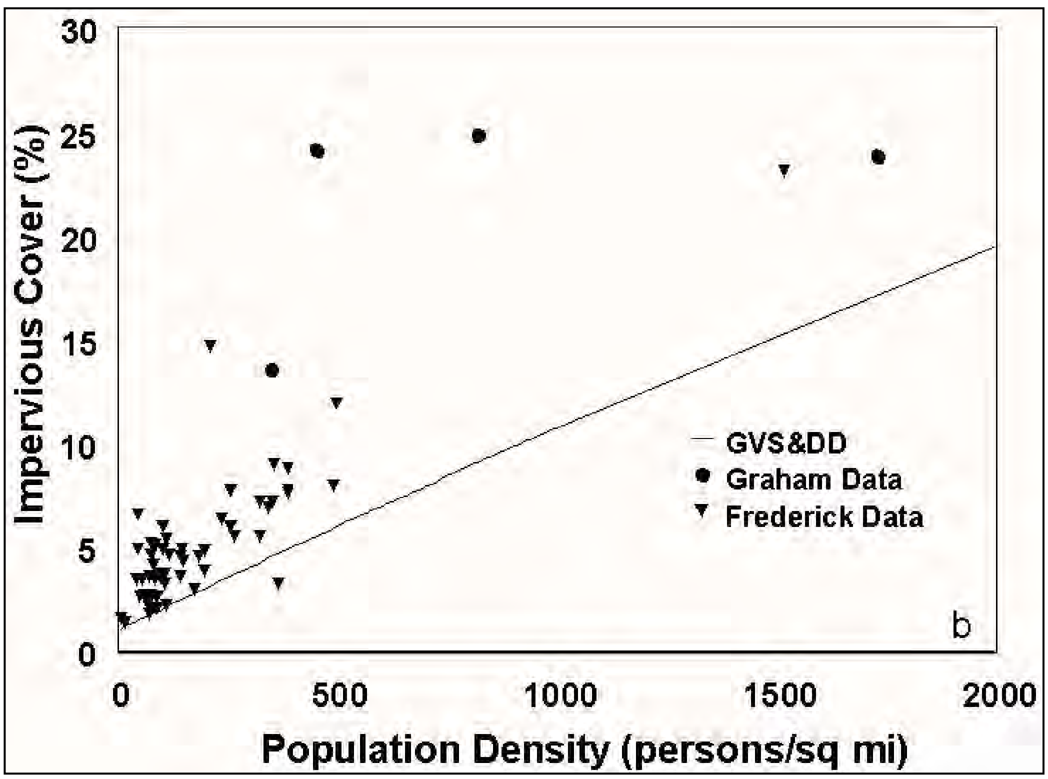
Figure 4-9: Waterbody classification scheme based on the relationship between watershed imperviousness and degradation of receiving waters (adapted from Schueler 2000a and Arnold and Gibbons 1996)



Source: Sleavin et al., 2000

For this analysis of the potential water quality and aquatic ecosystem effects of projected US 281 induced development, the impervious cover level of 10 percent will be used as the point beyond which a probable impact is expected. The method used to estimate levels of impervious cover that may be expected to occur in association with the projected induced development in the north-central portion of the US 281 AOI is based on a series of studies that looked at the relationship between population density and watershed impervious cover. A compilation and analysis of these studies and a refinement of estimation techniques was conducted for the US Environmental Protection Agency by Exum et al. (2005). The relationship between population density and impervious cover is illustrated below in **Figure 4-10**. This data plot refers to three sets of data that were analyzed by Exum et al. (2005). The Graham Data refers to data from the Washington D.C. area and reported by Graham et al. (1974), the Frederick Data refers to data from Frederick County, Maryland and collected by Exum et al. (2005), and GVS&DD refers to data collected for the Greater Vancouver Sewerage and Drainage District (GVS&DD, 1999). It should be noted that the relationship provided by the Greater Vancouver Sewerage and Drainage District (GVS&DD), which is indicated by the straight line on the graph, was found to consistently underestimate verified levels of impervious cover for densities under 2,000 persons/square mile (Exum et al. 2005).

Figure 4-10: Relationships between population density and watershed impervious cover for population density up to 2,000 persons/square mile (representative of low to moderate density single-family development)



Source: Exum et al., 2005

The relationship described in Exum et al. (2005) and illustrated above indicates that a watershed imperviousness level of 10 percent is reached at population densities of between 500 and 900 persons per square mile.

Estimating Potential Future Indirect Water Quality Impacts

As illustrated by **Figure 4-8**, the area subject to US 281-induced development is primarily within the upper Guadalupe River drainage area, with lesser but not inconsequential amounts located in the Cibolo Creek and Dry Comal Creek drainage areas; a small amount occurs on lands draining directly to Canyon Lake. The small amount of direct drainage to Canyon Lake does not alleviate potential for water quality effects to this waterbody because pollutant loading to the upper Guadalupe River may affect Canyon Lake. There are no areas of projected induced development in the drainage areas for the Blanco River, the Guadalupe River below Canyon Dam, Salado Creek, Leon Creek, and the upper San Antonio River; thus, water quality effects related to induced development in these surface waterbodies is not anticipated. The areas of projected induced development in 2035 in the four affected drainage areas are summarized in **Table 4-18**.

Table 4-18: Areas within the AOI Subject to Induced Development: Surface Watersheds, Population, and Water Demand

Line	Area Designation	Acres[1]	Projected Population			Estimated Water Demand (AF/yr)[2]		
			2009	2035	Change (%)	2009	2035	Change (%)
1	AOI[3]	396,547	244,906	598,227	351,321 (143%)	37,034	90,470	53,436 (144%)
2	AOI over the Edwards Aquifer Recharge Zone	69,756	NA[4]	NA[4]	NA[4]	NA[4]	NA[4]	NA[4]
3	Induced development area within the AOI	17,584	4,568	19,842	15,274 (334%)	691	3,000	2,310 (334%)
4	Induced development area over the Edwards Aquifer Recharge Zone	610 – 687[5]	NA[4]	NA[4]	NA[4]	NA[4]	NA[4]	NA[4]
5	Induced development area in Upper Guadalupe R. watershed	12,658	3,218	12,602	9,384 (292%)	487	1,906	1,419 (292%)
6	Induced development area in Canyon Lake watershed	261	99	291	192 (193%)	14	44	29 (193%)

Table 4-18: Areas within the AOI Subject to Induced Development: Surface Watersheds, Population, and Water Demand

Line	Area Designation	Acres[1]	Projected Population			Estimated Water Demand (AF/yr)[2]		
			2009	2035	Change (%)	2009	2035	Change (%)
7	Subtotal: Induced development areas in Upper Guadalupe and Canyon Lake watersheds	12,919	3,317	12,892	9,576 (346%)	507	1,950	1,448 (285%)
8	Induced development area in Cibolo Creek watershed	3,161	695	4,717	4,022 (579%)	105	713	608 (579%)
9	Induced development area in Dry Comal Creek watershed	1,503	556	2,232	1,676 (302%)	84	337	253 (302%)
10	Subtotal: Induced development area in Cibolo Creek and Dry Comal Creek watersheds	4,442	1,251	6,949	5,698 (455%)	189	1,050	861 (455%)

Sources: SCTRWPG 2012; San Antonio Research (SAR 2010); US 281 EIS Project Team

[1] Acreage before adjustment reflecting three percent variation between Expressway and Elevated Build Alternatives.
[2] Based on SAWS water use objective of 135 gallons per day per person, converted to acre-feet per year
[3] AOI estimates are for cumulative population growth, including project- induced and other reasonably foreseeable sources.
[4] Population and water demand estimates for the area over Edwards Aquifer Recharge Zone are included within the induced development area estimates (line 3)
[5] Acreage range for Build Alternatives

Upper Guadalupe River

The population density projected by SA Research Corporation (see **Section 5.5.2 2035 Development Estimate based on Population Projections and Residential Absorption Analysis**) for the area draining to the upper Guadalupe River ranges from 162 persons/square mile for the least densely populated sector to 1,121 persons/square mile for the most densely populated sector. Two of five sectors draining to the upper Guadalupe River are projected to have population densities above 900 persons/square mile, and another sector is projected to have 499 persons/square mile in 2035 (see **Figure 5-14**). These population densities indicate levels of impervious cover that fall within the 10 to 25 percent range indicated on **Figure 4-9**, which would likely result in water quality and aquatic ecosystem impacts. As a point of comparison, 2009 population densities in the upper Guadalupe River drainage area within the AOI ranged from 53 to 317 persons/square mile (see **Figure 5-13**) which indicates that current levels of watershed impervious cover are less than 10 percent. The population densities projected for 2035 in areas of project-induced growth indicates probable substantial water quality and aquatic life impacts in the upper Guadalupe River and its tributaries. The notable aspect of the upper Guadalupe River as a high value water resource was discussed in **Section 4.3.4 Water Resources and Features**. The vulnerability of this segment of the river to water quality degradation associated with land development and urbanization is evidenced by the bacteria impairment of the upper Guadalupe River segment near Kerrville. Watershed sources, including but not limited to on-site wastewater systems and contaminated storm water runoff in the Kerrville area, have required implementation of a bacteria TMDL for the upper Guadalupe River to address a combination of wildlife, livestock, and development-related pollution in order to restore water quality levels required by the Texas Surface Water Quality Standards (TCEQ 2007).

It should be kept in mind that the development intensity or population density referred to above would not be uniformly distributed throughout the overall drainage area. The areas of expected induced development are concentrated in the sub-watersheds of Spring Branch, Cypress Creek and Rebecca Creek and an un-named tributary to the Guadalupe River on the north side of the river, and Swine Creek, Miller Creek and an un-named tributary to the Guadalupe River on the south side of the river. In these sub-watersheds, between 18 percent and 21 percent of the total watershed area, depending upon the Build Alternative, is likely to be affected by US 281 induced development. The population density and the resulting watershed imperviousness would be expected to be higher in these sub-watersheds, which are closer to US 281 and correspondingly lower in outlying areas.

The difference between the Build Alternatives is minimal in terms of acreage of projected induced development and translates into a similar magnitude of indirect water quality effects under the Preferred Expressway Alternative and the Elevated Expressway Alternative.

Canyon Lake

Canyon Lake reservoir is vulnerable to the effects of pollutant loadings to the upper Guadalupe River as well as from development in the watersheds draining directly to the reservoir. In addition to possible contamination by urban runoff constituents such as bacteria, oxygen demanding substances and heavy metals, a primary concern for Canyon Lake is the potential for nutrient enrichment associated with increased phosphorous loading to the reservoir. In assessment of water quality and nutrient enrichment in lakes and reservoirs, a trophic state index (TSI) is used to describe the level of algal growth, nutrients, and water transparency (TCEQ 2011a). The trophic states, as defined by the TCEQ (2011a), are described below:

- Oligotrophic: Clear waters with extreme clarity, low nutrient concentrations, little organic matter or sediment, and minimal biological activity.
- Mesotrophic: Waters with moderate nutrient concentrations and, therefore, more biological productivity. Waters may be lightly clouded by organic matter, sediment, suspended solids or algae.
- Eutrophic: Waters extremely rich in nutrient concentrations, with high biological productivity. Waters clouded by organic matter, sediment, suspended solids, and algae. Some species may be eliminated.
- Hypereutrophic: Very murky, highly productive waters due to excessive nutrient loading. Many clear water species cannot survive.

The trophic state and ranking of Canyon Lake from the last three statewide reservoir assessments is provided in **Table 4-19**.

Table 4-19: Trends in Trophic State* of Canyon Lake, based on TCEQ Water Quality Assessment Data

Assessment Year	Chlorophyll A TSI / Statewide Rank*	Total Phosphorous TSI	Secchi Disc TSI	Trophic Class
2004	36.6 / 3	57.6	41.3	Mesotrophic
2006	53.5 / 53	60.6	43.5	Eutrophic
2008	47.3 / 25	52.3	45.1	Eutrophic
2010	47.7/20	52.6	45.6	Eutrophic

*Trophic classification: determined by the Trophic State Index (TSI) to be Oligotrophic (TSI 0-35), Mesotrophic (TSI >35-45), Eutrophic (TSI >45-55) or Hypereutrophic (TSI >55). Statewide Rank is determined by the Chlorophyll A TSI; the higher the rank the better the lake quality.

As shown in **Table 4-19**, Canyon Lake reservoir has dropped in rank from third in the state in 2004 to 20th in 2010, although the Total Phosphorous TSI as well as the Chlorophyll A TSI improved from 2006 to 2010.

The expected increase in pollutant loadings, including phosphorous loadings, in the watershed area draining to Canyon Lake due to projected suburban development in the US 281 induced development areas indicates a probable substantial water quality impact to Canyon Lake. Although it is reasonable to expect an increase in pollutant loading to the lake as a result of residential development (EPA 1999; Dennis 1986; Walker 1987), it is not possible to estimate future nutrient loadings or concentrations due to uncertainties regarding the locations and designs of future development and associated infrastructure such as storm water control systems and wastewater treatment. However, it is recognized that storm water treatment systems have a limited capacity to remove nutrients. Moreover phosphorous and nitrogen levels in storm water from developed areas manifest the phenomenon of irreducible pollutant concentrations (Schuler 2000b), which typically exceed background levels from undeveloped lands even after treatment by structural storm water controls, which have been shown to cause nutrient enrichment in lakes.

Cibolo and Dry Comal Creeks

These creeks, which recharge the Edwards Aquifer within and downstream of the AOI, would be affected by US 281-induced development to a lesser degree than the upper Guadalupe River and Canyon Lake, as shown on **Figure 4-8**. However, there is a potential for some level of water quality degradation associated with storm water runoff from induced development areas, which may be substantial in the tributaries where the development occurs. The vulnerability of these two stream segments is evident from their status on the TCEQ 303(d) List of impaired waters. Specific segments of both Upper Cibolo Creek (Segment 1908) and Dry Comal Creek (Segment 1811A) have been listed for bacteria pollution from 2000 to 2008. In 2012, Upper Cibolo Creek was also listed for chloride for the first time. Dry Comal Creek was listed for bacteria in 2000, was removed from the listing in 2002, and was re-listed on the 2010 303(d) List. This segment also appears on the 2012 303(d) List for bacterial contamination.

Groundwater

There is a potential for water quality effects to the Edwards Aquifer related to induced development. There are two potential pathways for contamination whereby storm water runoff from induced development may impact water quality in the aquifer: (1) storm water from developed areas on the Edwards Aquifer Contributing Zone that is transported by Cibolo and Dry Comal creeks, which recharge the aquifer within and downstream of the AOI; and, (2) the potential for direct recharge of the aquifer by contaminants in storm water on the portion of the induced development area that is projected to occur over the Edwards Aquifer Recharge Zone.

It should be noted that the upper Guadalupe River and Canyon Lake drainage areas within the AOI, while within the watersheds of the Edwards Aquifer Contributing Zone, are not considered to be effective contributing areas for the purposes of this water quality analysis, because of the overwhelming influence of Canyon Dam on water quality characteristics. Clearly, the surface water in these watersheds is released to the middle Guadalupe River segment, which recharges the Edwards Aquifer downstream of Canyon Dam. However, the dam and reservoir influence the water quality through detention, settling and accumulation processes that alter pollutants before the water is released below Canyon Dam. Pollutants such as bacteria and oxygen-demanding substances may be degraded, while other more persistent pollutants such as nutrients and heavy metals tend to accumulate in biomass and sediments. As can be seen on **Figure 4-8**, there is no induced development projected to occur in the other AOI drainage areas that are within the Edwards Aquifer Contributing Zone and/or Recharge Zone, including the upper San Antonio River, Salado Creek, and the Blanco River drainages.

Summary of Potential Indirect Groundwater Effects on the Edwards Aquifer including Comal Springs

The Final EIS sections describing direct, indirect, and cumulative groundwater impacts emphasize the sensitivity of the Edwards Aquifer to development. With respect to indirect (encroachment) impacts to groundwater, under the No-Build Alternative, the modeled groundwater flow paths linking the area near the US 281 ROW with Comal Springs will continue to flow, and vehicular traffic on the roadway will continue to increase. An important change to existing roadway conditions associated with each of the Build Alternatives would be the inclusion in the project design of runoff control and retention structures required by the TCEQ Edwards Aquifer Rules, which would minimize the likelihood that roadway runoff, including pollutants from vehicular spill events, would reach recharge features near the ROW, which in turn could enter the northeast trending flow path toward Comal Springs. (See **Section 3.9.2 Water Quality – Groundwater** and **Figure 3-34**).

With respect to aquifer contamination from urban runoff associated with induced development, the preceding analysis concludes that adverse effects on the aquifer are likely to be very minor or negligible. The induced development-related water quality effects are probable, yet they are considered to be of limited magnitude due to the relatively small extent of induced development that is projected to occur in the Cibolo and Dry Comal drainage areas, which comprise a relatively minor proportion of the total drainage area within the AOI. **Figure 4-8** shows the relationships between the AOI surface watersheds, the induced development zone, and the Edwards Aquifer Recharge Zone. The induced development area predicted to occur within the Cibolo and Dry Creek drainage areas is between approximately 4,400 acres and 4,600 acres, including both recharge and contributing zones. This can be compared with a total of 96,811 acres of drainage area for Cibolo and Dry Comal watersheds within the AOI. **Table 4-18** shows the acreages for the AOI, the induced development area, the watershed boundaries, and the Edwards Aquifer Recharge Zone; it indicates that the induced development area predicted to occur over the Edwards Aquifer Recharge Zone is 610 acres for the Preferred Expressway Alternative, and 687 acres for the Elevated Expressway Alternative. These are considered to be minor, but not inconsequential, amounts of development acreage relative to the total of 69,756 acres in the AOI over the Recharge Zone. In relative terms, the predicted induced development in the Cibolo and Dry Comal drainage areas represents five percent of their drainage areas within the AOI. The projected induced development over the Edwards Aquifer Recharge Zone would affect about one percent of the Recharge Zone area within the AOI.

Groundwater Supply

Table 4-18 provides estimates of population growth and associated water demand for Bexar and Comal counties; the US 281 AOI; the induced development area within the AOI; and individual watersheds within the induced development area. Projections made by the South Central Texas Regional Planning Group (Region L) indicate that the population of Bexar and Comal counties is expected to grow by 509,771 persons between 2010 and 2030 (SCTRPG 2012). The analysis of cumulative population growth conducted for this EIS indicates the AOI may receive around up to 350,000 additional residents, or about 60 percent of Region L's projected two-county growth over this 20 year period (SAR 2010). The 2035 population growth attributed to the US 281 induced development area (shown in yellow on **Figure 4-8**) is approximately 20,200, which represents about six percent of the AOI growth. The demand for municipal water supplies associated with this growth was estimated based on the San Antonio Water System's (SAWS) per capita water usage objectives of 135 gallons per day per person (SAWS 2012), converted to acre-feet per year. The water requirements associated with the estimated total induced population growth is about 3,066 acre-feet/year.

The outlook for future water availability and potential shortages for the rapidly growing San Antonio region is discussed in **Chapter 5, Cumulative Effects**, at **Section 5.3.4 Water Resources - Groundwater**. The role played by the water demand potentially associated with induced development is focused on the Edwards Aquifer, the most prolific as well as the most vulnerable source of water in the region. The likelihood that future residents of the induced development area will rely on the Edwards Aquifer for their water needs is related to, among other factors, their geographic location within the induced area. As described previously, the largest portion of the induced development area is within the Upper Guadalupe and Canyon Lake watersheds, which do not substantially contribute to Edwards Aquifer recharge. Similarly, those watersheds in western Comal County, which lie within the Guadalupe basin, do not commonly rely on Edwards Aquifer water for municipal and other needs. Most of western Comal County lies outside the permitting jurisdiction boundary of the Edwards Aquifer. Excluding the Upper Guadalupe and Canyon Lake watersheds from the estimated induced water demand reduces the water requirement likely to be addressed by the Edwards Aquifer to about 1,600 acre-feet/year. In the context of water requirements identified for the northern San Antonio region (Bexar and Comal counties), the water supply impact related to the proposed project's induced development is relatively minor.

Other considerations affecting water availability for future project-related growth, as well as for the region in general, include the prospective implementation of water development strategies identified in the SCTRWP Water Plan, the requirements for EAA critical period restrictions imposed by the EARIP HCP for protection of endangered and threatened species at San Marcos and Comal Springs, continuing advances in water conservation programs of SAWS and other water suppliers, and future drought and climate change effects on recharge and discharge from the aquifer.

Vegetation and Wildlife Habitat

Land development expected to occur in the US 281 induced growth areas would be expected to result in effects to vegetation and wildlife habitat. The types of expected effects include habitat fragmentation for resident wildlife and migratory birds, as well as the loss and other alteration of vegetation cover types and wildlife habitat. This would be a continuation of an ongoing regional trend where wildlife habitat of higher quality (e.g., native prairies, mature and old growth woodlands) has historically declined in favor of more fragmented, younger, less diverse vegetation communities in both uplands and in riparian corridors. Such alterations would be expected to affect wildlife species composition, distribution, and abundance, with a trend toward increases in those wildlife species that are adaptable to human disturbance and local increases in human population.

An estimate of the different vegetation types potentially affected within the areas projected for induced growth by the Build Alternatives is provided in **Table 4-20**.

This analysis is based on the extent of different vegetation types within the study area, as estimated by the TPWD EMST vegetation mapping (TPWD 2010h). As shown on **Table 4-20**, which provides estimates by alternatives, 63 percent of the potential impacts from land development within the induced development area of potential impacts would affect the oak-juniper upland woods/forest vegetation cover type. Another 19 percent of the potential impacts from land development within the induced development area would potentially affect the grasses and forbs vegetation cover type, and about 13 percent of the future development would be expected to occur in areas mapped as oak-juniper-mesquite shrub/brush. More detailed descriptions of the location, extent and nature of future vegetation and wildlife habitat indirect impacts related to induced growth cannot be reliably provided, given a lack of information on the designs and footprints of future land development projects.

Table 4-20: Areas of Potential Induced Development Impacts by Vegetation Cover Types in the AOI

Vegetation Cover Type	Induced Development (Acres of Potential Impact)		Acres in AOI
	Preferred Expressway Alternative	Elevated Expressway Alternative	
Oak-Juniper Upland Woods/Forest	11,627	11,989	156,721
Grasses and Forbes	3,531	3,606	55,398
Oak-Juniper-Elm Upland Parks & Woods	40	40	734
Riparian Woods and Forests	424	438	11,803
Oak-Juniper-Mesquite Shrub/Brush	2,384	2,441	35,838
Sparsely Vegetated/Urban	432	442	42,365
Crops	135	139	1,865
Water	1	1	8,430
Swamp	0	0	4
Areas where final vegetation cover data not available	0	0	43,389
Total	**18,574**	**19,096**	**356,547**

Source: TPWD 2010 and US 281 EIS Team, 2011.

4.6.4 Evaluation of Analysis Results

The analysis in the preceding sections discusses the conclusions regarding several encroachment-alteration effects and induced growth effects of the proposed project. These conclusions are summarized in **Table 4-21**.

Table 4-21: Summary of Indirect Effects Analysis

	Encroachment-Alteration Effects		Effects Related to Induced Growth	
	Preferred Expressway Alternative	Elevated Expressway Alternative	Preferred Expressway Alternative	Elevated Expressway Alternative
Community Resources, Visual & Aesthetic Qualities	No substantial encroachment-alteration effects.	Potentially substantial encroachment-alteration effects on roadway viewers associated with elevated roadway structures.	No substantial indirect effects associated with induced growth.	
Community Resources, Other Community Effects	There is an expected beneficial impact of improved safety for community members traveling on US 281 and cross streets.		No substantial indirect effects associated with induced growth.	

Table 4-21: Summary of Indirect Effects Analysis

	Encroachment-Alteration Effects		Effects Related to Induced Growth	
	Preferred Expressway Alternative	Elevated Expressway Alternative	Preferred Expressway Alternative	Elevated Expressway Alternative
Ecological Resources, Vegetation & Wildlife	No substantial encroachment-alteration effects, other than those considered for Threatened and Endangered Species. Minor effects on further fragmentation of woodland habitat areas that are already disturbed.		Indirect effects to vegetation and habitat for non-listed wildlife have not been quantified. Potential wildlife habitat impacts on approximately 18,574 areas of residential and associated commercial development projected to be induced by US 281 Expressway Alternative. The extent of actual habitat areas affected cannot be quantified because the design and footprint of future development is not known.	Indirect effects to vegetation and habitat for non-listed wildlife have not been quantified. Potential wildlife habitat impacts on approximately 19,096 areas of residential and associated commercial development projected to be induced by US 281 Elevated Expressway Alternative.
Ecological Resources, Threatened and Endangered Species **Golden-cheeked Warbler**	No substantial encroachment-alteration effects on the GCWA are expected due to absence of species in the corridor and habitat deterioration.		Substantial impacts to GCWA could occur within 5,057 to 7,417 acres of potential, but unverified, GCWA habitat that coincides with areas where US 281-induced development is projected to occur.	Substantial impacts to GCWA could occur within 5,263 to 7,668 acres of potential, but unverified, GCWA habitat that coincides with areas where US 281-induced development is projected to occur.

Table 4-21: Summary of Indirect Effects Analysis

	Encroachment-Alteration Effects		Effects Related to Induced Growth	
	Preferred Expressway Alternative	Elevated Expressway Alternative	Preferred Expressway Alternative	Elevated Expressway Alternative
Ecological Resources, Threatened and Endangered Species **Other Listed Species**	For federally-listed karst invertebrates, biological investigations have been completed at all known and accessible karst habitat and no listed species have been encountered. Any karst habitat that could potentially be affected does not have a surface connection so surface vegetation clearing would not alter cave cricket foraging areas. The surface drainage basins of the caves in CHU 12 are at higher elevations than the proposed project; therefore they would not be altered. The subsurface drainage basins are not currently known, so it may be possible that *R. exilis* could be indirectly affected if the project actions modify nutrient and water inputs or introduce contaminants into the subsurface drainage basins. The USFWS lists conservation measures that must be taken in its Biological Opinion and incidental take has been authorized within a 1,530 acre area where direct and indirect impacts could occur (see **Appendix I4**). It is the USFWS' biological opinion that the action, as proposed, is not likely to jeopardize the continued existence of *C. madla, R. exilis* and *R. infernalis*, nor result in the adverse modification of destruction of designated critical habitat and that the authorized take would not result in the destruction or adverse modification of designated critical habitat within CHU 12 for *R. exilis.* No potential encroachment-alteration effects on species dependent on Comal Springs are expected due to the distance of the US 281 Corridor Project from Comal Springs (approximately 20 miles), the fact the this project is a widening of an existing roadway and the pollutant removal which would be achieved with TCEQ storm water BMPs.		No substantial indirect effects to the BCVI are anticipated because no habitat has been identified. There is no known occupied habitat for federally-listed karst invertebrates within the induced development area, therefore, no impacts are anticipated. Karst habitats outside of Bexar County have not been biologically investigated. Given the distance of the US 281 Corridor Project from Comal Springs (approximately 20 miles) and the TSS removal which would be achieved with TCEQ-approved storm water BMPs, indirect effects resulting from the US 281 Corridor Project on Comal Springs dependent species are not reasonable certain to occur in the future. Unknown amounts of habitat for state-listed Texas horned lizard may be impacted. There is a low potential for indirect impacts to the Cagle's Map Turtle in the upper Guadalupe River and its tributaries. No substantial indirect impacts to state-listed mussel species are anticipated.	

Table 4-21: Summary of Indirect Effects Analysis

<table>
<tr><th rowspan="2"></th><th colspan="2">Encroachment-Alteration Effects</th><th colspan="2">Effects Related to Induced Growth</th></tr>
<tr><th>Preferred Expressway Alternative</th><th>Elevated Expressway Alternative</th><th>Preferred Expressway Alternative</th><th>Elevated Expressway Alternative</th></tr>
<tr><td rowspan="2">Water Quality and Quantity

Surface Waters</td><td colspan="2" rowspan="2">There are probable substantial encroachment-alteration effects to surface water quality associated with contaminated runoff from the roadway entering waterbodies, including possible effects related to hazardous materials spills.

The addition of impervious cover would have the encroachment-alteration effect of decreasing water infiltration on site and increasing the amount of runoff; some of which would ultimately flow downstream.</td><td>There are probable substantial impacts to surface water quality related to development of approximately 18,574 acres of residential and associated commercial development projected to be induced by US 281 Expressway Alternative.</td><td>There are probable substantial impacts to surface water quality related to development of approximately 19,096 acres of residential and associated commercial development projected to be induced by US 281 Elevated Expressway Alternative.</td></tr>
<tr><td colspan="2">Impacts are associated with anticipated watershed changes, including increased impervious cover, and contaminated runoff from future development areas. A greater degree of impacts are expected to the upper Guadalupe River and its tributaries and to Canyon Lake; a lesser degree of impacts are expected in the Cibolo Creek and Dry Comal Creek drainage areas.

Induced growth would result in increased demand for water supply. Some of the induced development area would rely on surface waters for their water supply.</td></tr>
<tr><td rowspan="2">Water Quality and Quantity

Groundwater, Including Edwards Aquifer</td><td colspan="2" rowspan="2">There are probable substantial encroachment-alteration effects to groundwater quality associated with the potential for contaminated runoff to enter the Edwards Aquifer and/or Trinity Aquifer, including possible effects related to hazardous materials spills.

Encroachment-alteration effects to groundwater quantity could occur as a result of surface and subsurface modifications. Changes to flow regimes could impact the recharge and discharge features present outside the proposed ROW for the US 281 Corridor Project.</td><td>There are probable impacts to groundwater quality related to development of approximately 4,442 acres of residential and associated commercial development projected to be induced by US 281 Expressway Alternative in areas considered to affect recharge of the Edwards Aquifer, including approximately 610 acres of development on the Recharge Zone.</td><td>There are probable impacts to groundwater quality related to development of approximately 4,592 acres of residential and associated commercial development projected to be induced by US 281 Elevated Expressway Alternative in areas considered to affect recharge of the Edwards Aquifer, including approximately 690 acres of development on the Recharge Zone.</td></tr>
<tr><td colspan="2">Impacts are associated with anticipated watershed changes, including increased impervious cover, and contaminated runoff from future development areas in the Cibolo Creek and Dry Comal Creek drainage areas. Due to the limited extent of the development areas in relation to larger Recharge and Contributing zones, impacts to groundwater quality and recharge are expected to be of limited magnitude.

The largest portion of the induced development area does not commonly rely on Edwards Aquifer water for municipal or other needs. However, some of the water demand generated by induced growth would be sourced from the Edwards Aquifer.</td></tr>
</table>

1 Source: US 281 EIS Team, 2011

4.7 STEP 7: ASSESS CONSEQUENCES AND CONSIDER/DEVELOP MITIGATION (WHEN APPROPRIATE)

Because mitigation, in the NEPA context, implies actions or commitments that go beyond basic compliance, the existing and expected regulatory requirements associated with each resource type establish a baseline level of resource protection to consider in an evaluation of the need for mitigation. There is a range of public and private programs and initiatives which could potentially be applied to address and mitigate indirect effects within the US 281 AOI in ways that go beyond regulatory compliance.

FHWA policy limits the use of federal funds for mitigation to impacts that can be shown to "actually result from the Administration actions" (23 CFR Sec. 771.105), effectively limiting consideration of mitigation commitments for indirect impacts. TxDOT (2009c) notes that implementing a needed mitigation measure for indirect <u>or</u> cumulative impacts "is often beyond the jurisdiction of FHWA, TxDOT, or other cooperating agencies". In such cases, the guidance recommends listing the agencies that have regulatory authority, recommending actions that other agencies might take, and thereby disclosing the mitigation needs to the public. The kind of broad-based, long term indirect effects that are likely to be associated with the proposed US 281 Corridor Project would probably be resistant to simple or direct mitigation initiatives within the jurisdiction of one or even a few responsible agencies.

In a high growth area like the US 281 AOI, where the potential for both induced and other foreseeable future development is substantial, it is difficult to sort out cause-effect impact relationships in a way that would clearly point to any single action or program with respect to particular mitigation responsibilities. A message that was reinforced by the land use and planning experts is that the challenges to the sustainability of resources in the AOI transcend jurisdictional boundaries and would require continued cooperative efforts of all stakeholders and institutions, both public and private, over the 25-year planning period. The framing of impact issues and detailed exposition of reasonable mitigation options to the appropriate audiences is therefore a key objective for both the Indirect and Cumulative Effects analyses within the US 281 NEPA process.

Additional Land Use Panel Comments on Mitigation Strategies

At the second Indirect Impacts workshop, land use panel participants were asked to identify resource protection and land use management tools currently available to respond to expected growth within the AOI, as well as comment on the effectiveness of each tool. Panel members listed mitigation measures they were aware of for the AOI, which included:

- Edwards Aquifer Rules
- Local land development regulations
- TxDOT hazardous materials regulations
- Private land banks

Further discussion of mitigation measures with the panel revealed that one participant felt public policy does not significantly affect growth. For example, San Antonio policymakers have tried to encourage growth on the south side of the city, but growth continues to occur mainly toward the north. He considered other factors, such as school systems and housing, more influential than public policy in terms of growth and development. Another participant stated that "Texas wants people to choose what they want to happen." This can be seen in the case of Comal County, where a voluntary land preservation program has been initiated, resulting in increased flexibility for land owners to conserve their land instead of reluctantly selling to developers. Concern over water quality and availability was a major concern for participants as well. Mitigation measures cited to protect water resources included selling water rights, restricting development, and the eventual necessity for water and wastewater treatment plants. Finally, a participant proposed incentives for citizens to "do the right thing;" however, it was pointed out that though people are concerned about drinking water, they may not fully understand its source. Education, panel members agreed, is a crucial tool in mitigating adverse effects on the environment.

Mitigation Measures for Effects Related to Induced Growth

There are a number of available mitigation measures that are applicable to achieving the goal of minimizing identified probable impacts associated with future suburban land development activities in the areas where US 281-induced development and other un-related development are projected to occur. These measures generally fall into the category of development planning and design measures (**Table 5-21**). Within the discipline of land development planning and design practices, an emerging practice known as Low Impact Development (LID) has been shown to have high potential for reducing levels of water quality impacts as compared to traditional development designs. In addition, development designs that integrate important environmental resource conservation elements through establishment of strategically located greenbelt areas and corridors, as well as the clustering of buildings and transportation systems may facilitate conservation of critical habitat elements.

The potential applicability and more site-specific definition of these types of mitigation measures to future land development within the AOI should be evaluated and determined through cooperative work among the primary interested parties and other stakeholders in the projected future development areas identified in the AOI. The parties to such a discussion would include: land owners; land development professionals; builders and construction industry representatives; chambers of commerce; local government planning and regulatory officials; regional water authorities, including the EAA, Guadalupe Blanco River Authority, and the Upper Guadalupe River Authority; state resource agencies such as the Texas Parks and Wildlife Department, Texas Commission on Environmental Quality, and the Texas State Soil and Water Conservation Board; transportation planning entities, including the FHWA, TxDOT, the Alamo Regional Mobility Authority (Alamo RMA) and transit authorities; school districts; water and wastewater service providers; non-governmental environmental organizations; and other interested members of the community.

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